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Volume 16, The Second SeaWiFS Intercalibration Round-Robin Experiment, SIRREX-2, June 1993

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ABSTRACT

This report presents the results of the second Sea-viewing Wide Field-of-view Sensor (SeaWiFS) Intercalibration Round-Robin Experiment (SIRREX-2), which was held at the Center for Hydro-Optics and Remote Sensing (CHORS) at San Diego State University (SDSU) on 14-25 June 1993. SeaWiFS is an ocean color radiometer that is scheduled for launch in 1994. The SIRREXs are part of the SeaWiFS Calibration and Validation Program that includes the National Aeronautics and Space Administration's (NASA) Goddard Space Flight Center (GSFC), CHORS, the National Institute of Standards and Technology (NIST), and several other laboratories. GSFC maintains the radiometric scales (spectral radiance and irradiance) for the SeaWiFS program using spectral irradiance standard lamps, which are calibrated by NIST. The purpose of each SIRREX is to assure that the radiometric scales which are realized by the laboratories who participate in the SeaWiFS Calibration and Validation Program are correct; that is, the uncertainties of the radiometric scales are such that measurements of normalized water-leaving radiance using oceanographic radiometers have uncertainties of 5%. SIRREX-1 demonstrated, from the internal consistency of the results, that the program goals would not be met without improvements to the instrumentation. The results of SIRREX-2 demonstrate that spectral irradiance scales realized using the GSFC standard irradiance lamp (F269) are consistent with the program goals, as the uncertainty of these measurements is assessed to be about 1%. However, this is not true for the spectral radiance scales, where again the internal consistency of the results is used to assess the uncertainty. This is attributed to inadequate performance and characterization of the instrumentation. For example, spatial non-uniformities, spectral features, and sensitivity to illumination configuration were observed in some of the integrating sphere sources. The results of SIRREX-2 clearly indicate the direction for future work, with the main emphasis on instrument characterization and the assessment of the measurement uncertainties so that the results may be stated in a more definitive manner.

1. INTRODUCTION

The Sea-viewing Wide Field-of-view Sensor (SeaWiFS) ocean color radiometer is scheduled to be launched in 1994 and operated in a sun synchronous orbit for five years. The National Aeronautics and Space Administration (NASA) will carry out a program to acquire the global SeaWiFS data set, validate and monitor its accuracy and quality, process the radiometric data into geophysical units, and distribute it to the scientific community in the United States and abroad. The SeaWiFS data products figure as a prominent component of major scientific programs, including the Joint Global Ocean Flux Study (JGOFS) and Global Ecosystem (GLOBEC) programs, aimed at improving our understanding of global change.

Two important goals of NASA's SeaWiFS program are to determine, from the SeaWiFS radiance measurements, 1) normalized water-leaving radiance with an uncertainty of 5%, and 2) chlorophyll *a* concentration with an uncertainty of 30%. All uncertainties are expressed as standard deviations, σ , unless otherwise noted. These goals are very ambitious, and can only be achieved by augmenting the SeaWiFS measurements with a program of ongoing validation measurements to verify the radiometric uncertainty and long-term stability of the SeaWiFS instrument's radiance responsivities, and to validate the atmospheric correction models and algorithms used to convert SeaWiFS radiances to normalized waterleaving radiances. One of

the principal approaches to this critical aspect of validation will be frequent direct comparisons between SeaWiFS estimates and *in situ* measurements of water-leaving radiance. Because the primary goal is to demonstrate that normalized water-leaving radiances derived from SeaWiFS data have uncertainties of less than 5%, the comparative *in situ* radiometric measurements must be calibrated to an uncertainty less than 5%.

The only economically feasible approach to acquiring a large and globally distributed sample of *in situ* radiometric measurements for SeaWiFS validation, is to solicit contributions of data from the oceanographic community at large, and to somehow provide assurance that the aggregate data set will be of uniform quality and have an uncertainty less than 5% (or at least be internally consistent to that level). The SeaWiFS Project at NASA's Goddard Space Flight Center (GSFC) is addressing this problem through the SeaWiFS Calibration and Validation Program (McClain et al. 1992). At the outset, the Project sponsored a workshop to draft protocols for ocean optics measurements to support SeaWiFS validation (Mueller and Austin 1992), which include instrument performance specifications, and requirements for instrument characterization and calibration.

Of the oceanographers and institutions expected to contribute ocean radiometric measurements to the SeaWiFS validation database, only a few are equipped to calibrate and characterize radiometric instruments. Laboratories

which currently engage in at least some aspects of the characterization and calibration of oceanographic radiometers include GSFC; the Center for Hydro-Optics and Remote Sensing (CHORS) at San Diego State University (SDSU); the University of Miami (UM); the University of California at Santa Barbara (UCSB); the University of Arizona (UA); the Moss Landing Marine Laboratory (MLML) in collaboration with Dennis Clark of the National Oceanic and Atmospheric Administration (NOAA); and several manufacturers of instruments including Biospherical Instruments, Inc. (BSI) in San Diego, California, and Satlantic, Inc. in Halifax, Nova Scotia, Canada. The SeaWiFS instrument is being characterized and calibrated by its manufacturer, the Hughes Santa Barbara Research Corporation (SBRC).

The strategy adopted for SeaWiFS validation is to calibrate all involved instruments within the network consisting of these, and possibly a few additional laboratories. In recognition of the need to maintain internal consistency between calibrations of *in situ* instruments and that of the SeaWiFS instrument itself, the SeaWiFS Project, under the Calibration and Validation Program, has implemented an ongoing series of SeaWiFS Intercalibration Round-Robin Experiments (SIRREXs). The purpose of this program to transfer the National Institute of Standards and Technology (NIST) scales of spectral irradiance and radiance, through GSFC, to all participating laboratories in the SeaWiFS ocean community, and to the calibration standards used to calibrate the SeaWiFS instrument for radiance responsivity.

The specific objectives of the SIRREX series are to:

1. intercalibrate FEL lamp working standards of spectral irradiance used at the participating laboratories, and to reference each to the NIST scale of spectral irradiance by way of a secondary standard (FEL lamp F269) to be maintained at GSFC;
2. intercalibrate integrating sphere sources of spectral radiance used at the various laboratories;
3. intercompare plaques used to transfer the scale of spectral irradiance from an FEL lamp to a scale of spectral radiance; and
4. intercompare transfer radiometers and other support electronics, most critically shunts and voltmeters, used to support radiometric calibrations at each laboratory.

The first SIRREX was held at CHORS in San Diego, California on 27–31 July 1992, the results of which were presented in Mueller (1993). This work demonstrated that the NIST scales of spectral irradiance were *not* transferred from FEL lamp F269 to the 17 other lamps with an uncertainty of near 1%. An uncertainty of 1% is expected, based on the uncertainty in the NIST scale of spectral irradiance, and general experience with the process of transferring spectral irradiance scales using monochromators. (Refer to Walker et al. 1987, however, note that Walker's

uncertainties correspond to three σ values.) Experience was gained at SIRREX-1 in the methods of comparing the spectral radiance scales of sphere and plaque sources, as well as the voltmeters and resistors that are used to determine lamp operating currents.

The Second Round-Robin Intercalibration Experiment (SIRREX-2), was held at CHORS on 14–25 June 1993. Conventions used for names, formats, and headers in the data files comprising the SIRREX-2 data set will be given in Volume 20 of the *SeaWiFS Technical Report Series*. Appendix A (in this document) lists the organizations involved with SIRREX-2, along with the point(s) of contact; the instruments tested and measured; and the diameters and areas of these instruments—the dimensions of which are given in both the International System of Units (SI), or *Système International d'Unités*, and inches. The participants in SIRREX-2 are listed in Appendix B. Appendix C gives the results of uniformity studies of the GSFC sphere performed after SIRREX-2. This report documents SIRREX-2 results for:

a. *Lamps*: The transfer of the spectral irradiance scale of FEL lamp F269 to lamps belonging to participating laboratories, is accomplished by using an Optronics 746† spectroradiometer with an integrating sphere irradiance collector (ISIC), which is referred to as the 746/ISIC.

b. *Spheres*: The transfer of the spectral irradiance scale of FEL lamp F269, using the 746/ISIC, to determine the scales of spectral reflectance of the GSFC, BSI, CHORS, UCSB, and the GSFC Wallops Flight Facility (WFF) integrating spheres. The secondary transfer is also reported, using a commercial Photo Research (PR) 714 SpectraScan spectroradiometer (provided by NIST), of the spectral radiance scale of the GSFC

sphere to the other above mentioned spheres and to the NOAA Optronics 420M sphere. (See Appendix A for information regarding diameters of these spheres.) Radiance measurements with the BSI 6-channel transfer radiometer (BSIXR) are also reported for each sphere. Radiance measurements of each sphere with the SeaWiFS Transfer Radiometer (SXR) were analyzed. In addition, radiance measurements of some spheres were made with the Satlantic 7-channel transfer radiometer (OCR100), for which the data were analyzed by S. McLean of Satlantic. Radiance measurements made with the UA Transfer Radiometer (UAXR) are also being analyzed by S. Biggar at UA, however, results from that instrument are not available for this report.

† Identification of commercial equipment to specify adequately the experimental problem, does not imply recommendation or endorsement by the National Institute of Standards and Technology, nor does it imply that the equipment identified is necessarily the best available for the purpose.

c. *Plaques*: Approximate (0° , 45°) reflectance measurements, using the PR714, of seven SpectralonTM† plaques used to convert a lamp's spectral irradiance output to diffuse spectral radiance.

d. *Voltmeter and shunt* intercomparisons.

This report, as in Mueller (1993), does not describe in detail the uncertainties in the spectroradiometric scales as realized at the SIRREX; rather, the results are presented by comparison to independent values where possible. Obviously, the statement of the result of a measurement, such as the spectral radiance values determined by the transfer radiometers for the sphere sources, is incomplete without also stating the uncertainty of the measurement; but at the time of SIRREX-2, these data were not available. However, the results for SIRREX-2 are still informative, because uncertainties are demonstrated that reflect the internal consistency of the measurements, as well as the uncertainty in the absolute calibration of some of the sources and radiometers. For the sphere and plaque studies, SIRREX-2 demonstrates that significant problems remain with regard to realizing spectral radiance scales; these issues can be resolved only by complete characterization of the sources and radiometers. This issue, as well as a complete uncertainty analysis, should be addressed in the next SIRREX (see Section 3.3).

2. LAMP STANDARDS

All of the participating laboratories base absolute calibrations of irradiance and radiance instrument responsivities on the NIST scale of spectral irradiance, which is transferred to the scientific and engineering community in the United States via calibrated tungsten-halogen lamps (usually FEL lamps, and less frequently DXW lamps) (Walker et al. 1987). Some laboratories acquire a calibrated FEL lamp standard of spectral irradiance directly from NIST, but more typically, a laboratory will base its irradiance scale on a lamp which has been calibrated and certified as traceable to the NIST scale by a commercial standardizing laboratory. In all cases, a laboratory will purchase additional seasoned, but uncalibrated lamps, and transfer the spectral irradiance scale from their primary calibrated lamp using a transfer radiometer. These less expensive working standards are then used for calibrations to avoid building up hours on, and expending the useful working life of, the local primary reference lamp.

A laboratory will periodically intercompare all of their working standard lamps and their primary reference lamp to maintain an internally consistent scale of spectral irradiance, and to detect cases when a lamp begins to either become unstable, or to otherwise fail in a subtle way; a lamp usually becomes an unreliable source of spectral irradiance long before it burns out. The SIRREX program

extends this internal consistency maintenance throughout the several laboratories participating in the calibration of instruments for SeaWiFS validation.

2.1 Methods

During SIRREX-2, the spectral irradiance scale of the GSFC FEL lamp F269 was transferred to 26 other lamps belonging to the various participating laboratories. The F269 irradiance scale was recalibrated by NIST in October 1992, to provide a NIST traceable standard as the basis for intercalibration of all radiometers involved in the SeaWiFS validation. The second GSFC FEL lamp, F268, was also recalibrated by NIST to provide a working reference to verify the long term stability of F269, as the primary tie to the NIST scale of spectral irradiance.

Transfer of the F269 scale of spectral irradiance to other lamps follows the procedures for spectral irradiance calibrations described in Walker et al. (1987). A small ISIC is attached, at its exit port, to the entrance slit of an Optronics 746 spectroradiometer—a single-monochromator based radiometer system with a silicon detector. This spectroradiometer is equipped with an internal chopper, so that background dark signals are removed electronically.

For SIRREX-2, the 746/ISIC was configured with a blazed grating yielding a usable spectral range of measurements extending from 350–1,000 nm (in SIRREX-1, a different grating limited measurements to wavelengths greater than 400 nm). During and after SIRREX-1, it was discovered that the spectral responsivity of the 746/ISIC drifted over time, and that the rate of drift was especially rapid and erratic during the first two hours of operation (Mueller 1993). Therefore, for SIRREX-2 measurements, the 746/ISIC system was powered on to season overnight prior to its use in irradiance measurements.

Lamp F269 was mounted to illuminate the aperture of the 746/ISIC, which was placed normal to the center of the lamp filament at a distance of 50 cm (by convention, measured to the front surface of the lamp's electrical connection posts). The lamp was powered on and allowed to warm up for approximately 20 minutes. The irradiance responsivity of the 746/ISIC was then determined by measuring the known spectral irradiance output from lamp F269. The calibrated responsivity of the 746/ISIC was then used to measure the spectral irradiance emitted by each of the other lamps. The first measurement is always made immediately on the reference lamp, F269, to provide an initial measure of the transfer uncertainty. Each lamp was then powered down and replaced by the next lamp to be calibrated, which was allowed to warm up for approximately 15 minutes before its spectral irradiance output was measured with the 746/ISIC. This procedure was repeated until all lamps were calibrated.

At approximately two hour intervals, and near the end of each transfer session, the reference lamp, F269, was measured again to estimate the rate of drift of the radiometer's

† "Spectralon" is a registered trademark of Labsphere, Inc., North Sutton, New Hampshire

responsivity through the duration of the entire procedure. The F269 checks were not performed with this frequency during SIRREX-1, and unresolved responsivity drift was a serious source of error in those data. In the analysis of the SIRREX-2 746/ISIC lamp transfer data, the spectral responsivity of the 746/ISIC was adjusted to match the start time of each lamp transfer, by interpolation between bracketing F269 measurements. The stability of F269 itself was verified by comparison to F268 near the beginning and end of the entire sequence.

2.2 Results

The spectral irradiance scale of F269, calibrated by NIST in October 1992, was transferred to 25 other FEL lamps and 1 DXW lamp on 22–25 June 1993. Figure 1 compares the initial F269 transfer checks on each of the four days to each other, using the NIST October 1992 calibrated scale as a reference; agreement is within less than 1% at all wavelengths greater than or equal to 400 nm, but discrepancies increase to as much as 4% at lower wavelengths. This result quantifies the maximum internal uncertainty of the 746/ISIC lamp transfer setup and procedure, but gives no information on the uncertainty of the F269 scale itself. The transfers of the F269 scale to F268, and comparison to the October 1992 NIST scale for F268, provide the best estimate of the overall uncertainty of the F269 scale and transfer procedure. The transfers of the F269 scale to F268 (early on 22 June 1993 and late on 24 June 1993) are illustrated in Fig. 2. Agreement with the NIST (October 1992) F268 calibration scale was less than 1% for wavelengths greater than or equal to 400 nm, indicating that lamp F269 has remained relatively stable since its October 1992 calibration by NIST. There is, however, a consistent discrepancy of approximately 0.6% at all wavelengths, which suggests either that the irradiance output of F269 has increased, or that the output of F268 has decreased in the interim since the two lamps were calibrated by NIST.

Figures 3–5 illustrate the time series of F269 irradiance checks measured on 22–24 June, respectively. The responsivity of the 746/ISIC drifted with time on all three days. Therefore, the responsivity was adjusted to correspond to the time of each lamp transfer, by interpolating between bracketing F269 measurements. Drift of the 746/ISIC between F269 checks was less than 1% per hour in all cases. With this adjustment, it is estimated that the uncertainties in transfers from F269 were 1% for all lamps.

Irradiance scales of each lamp, as transferred from F269 with the 746/ISIC (responsivity temporally adjusted as described above), are listed in Tables 1 (GSFC and UM lamps), 2 (CHORS lamps), 3 (BSI and Satlantic lamps), 4 (UCSB and NOAA), and 5 (National Research Institute of Far Seas Fisheries [NRIFS] of Japan, UA, and SBRC). Spectral irradiance scales transferred from F269 during SIRREX-2 that were also measured during SIRREX-1, are

illustrated in Figs. 6–16 for lamps F303, F219, F321, F307, F308, F12G, F12H, 91534, F310, 90572, and 91348, respectively. In these figures, the SIRREX-2 results are also compared with the historical irradiance scales of each lamp, including the scales derived during SIRREX-1 (Mueller 1993).

The *Relative Difference* plots for the lamps in Figs. 1–16 illustrate the factor

$$\delta = 1 - \frac{E_{\text{meas}}(\lambda)}{E_{\text{ref}}(\lambda)}, \quad (1)$$

where E_{meas} and E_{ref} are measured and reference irradiance, respectively. To adjust E_{meas} , to force agreement with E_{ref} , take

$$E_{\text{ref}}(\lambda) = \frac{E_{\text{meas}}(\lambda)}{(1 - \delta)}. \quad (2)$$

Note that when E_{meas} exceeds the reference value, the relative difference is negative, and vice versa.

2.3 Discussion

Examination of Figs. 1–5 leads to the conclusion that the lamp transfers during SIRREX-2 were of much better quality than those attained during SIRREX-1 (Mueller 1993), and that an uncertainty of 1% can be attached to the transferred scales at wavelengths greater than 400 nm. This conclusion is based on the apparent stability of FEL lamp F269, as checked by the comparisons of the irradiance scales of F268 transferred from F269 with that calibrated by NIST in October 1992 (Figs. 1 and 2). Agreement is better than 1% at all wavelengths greater than 400 nm. Furthermore, although the 746/ISIC drifted by as much as 2.5% during the course of extended transfer sessions on each day (Figs. 3–5), significant drifts were monotonic in time, and rates were always less than 1% per hour. Therefore, the frequent F269 scale checks provide a firm basis for recalculating 746/ISIC spectral responsivity at any given time with an estimated uncertainty of less than 1%.

Figures 6–16 illustrate the results for the 11 lamps that were also measured during SIRREX-1; the results for the remaining 14 lamps can be found in Tables 1–5. These SIRREX-2 data are the only available spectral irradiance determinations for these 14 lamps. Comparison of the SIRREX-1 and SIRREX-2 results demonstrates that the uncertainty, as reflected by the internal consistency of the results, was between 2–6% for SIRREX-1 (with the poorest results on 31 July 1992) and between 1–2% for SIRREX-2. The improvement is attributed to the correction of the drift in the 746/ISIC by remeasuring FEL lamp F269 every two hours along with the changing of the grating, which resulted in increased throughput below 450 nm.

The SIRREX-2 scale for F307 (Fig. 9) agrees with the SIRREX-1 (30 July 1992) irradiance scale (above 430 nm) within 2%, and with the original calibration by Optronics to within less than 1.5%. The SIRREX-2 scale for F308

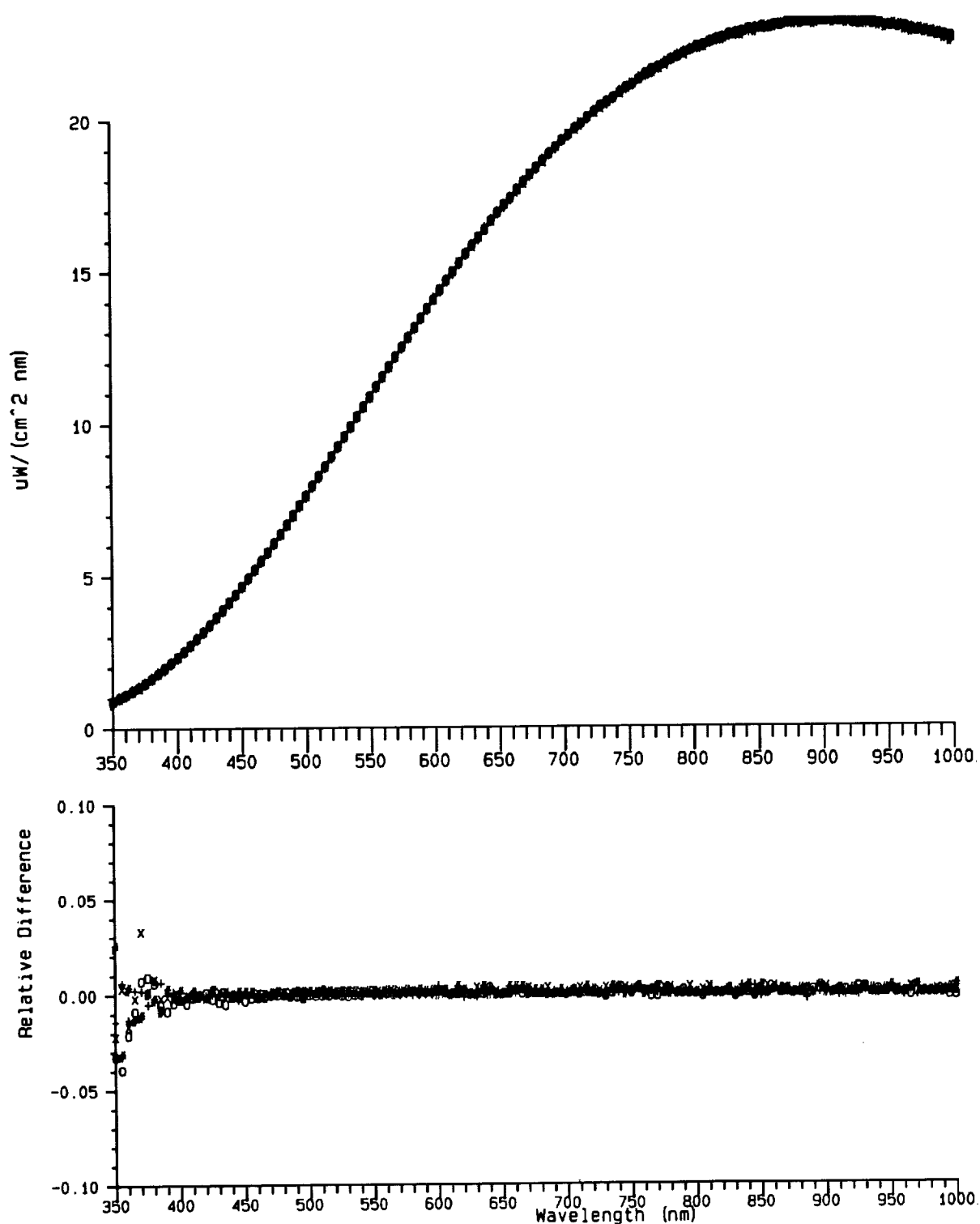


Fig. 1. Spectral irradiance of FEL lamp F269 measured during initial transfer checks on 22 (o), 23 (x), 24 (+), and 25 (#) June 1993, compared to the NIST (October 1992) calibrated F269 spectral irradiance scale (solid line in top panel). The top panel compares spectral irradiance scales in $\mu\text{W cm}^{-2} \text{ nm}^{-1}$, and the bottom panel illustrates errors relative to the NIST October 1992 calibration.

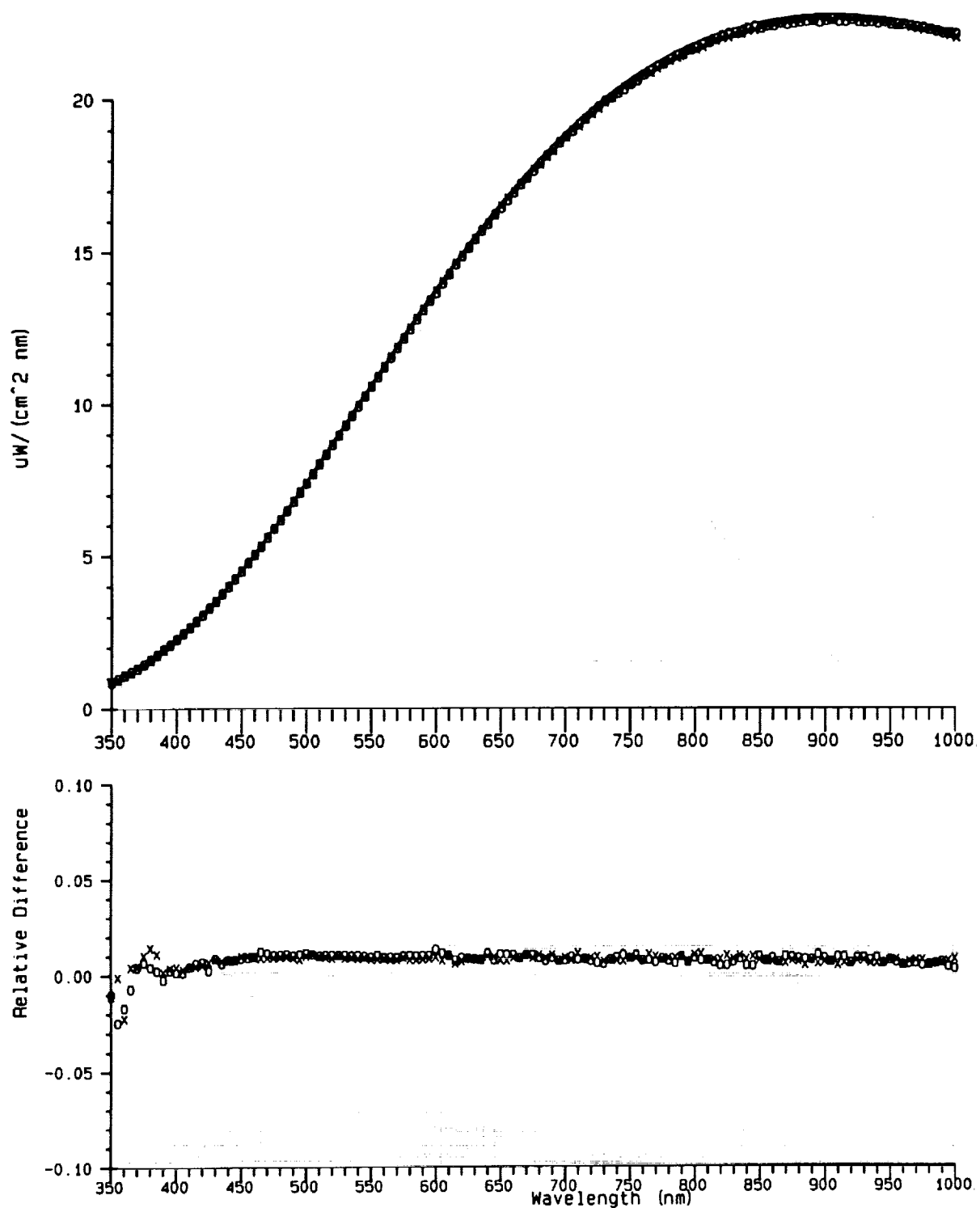


Fig. 2. Spectral irradiance of FEL lamp F268 measured, relative to the scale of lamp F269 on 22 (o) and 24 (+) June 1993, compared to the NIST (October 1992) calibrated F268 spectral irradiance scale (solid line in top panel). The top panel compares spectral irradiance scales in $\mu\text{W cm}^{-2} \text{ nm}^{-1}$, and the bottom panel illustrates errors relative to the NIST October 1992 calibration.

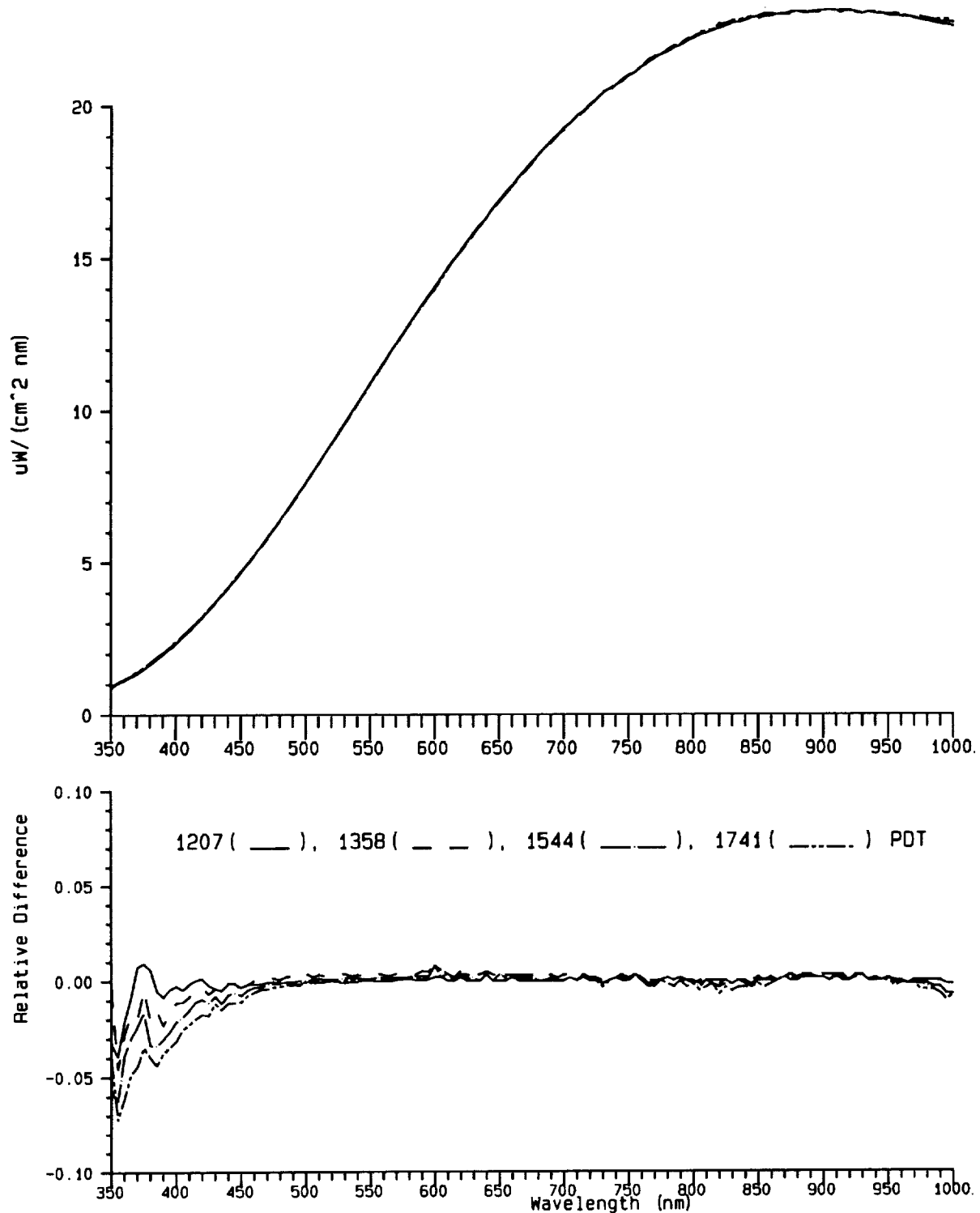


Fig. 3. Temporal change in apparent spectral irradiance of lamp F269, due to drift in the 746/ISIC, during the lamp spectral irradiance scale transfer of 22 June 1993. The top panel illustrates apparent spectral irradiance ($\mu\text{W cm}^{-2} \text{ nm}^{-1}$) at 1207, 1358, 1544, and 1741 Pacific Daylight Time (PDT) (see legend in lower panel). The bottom panel illustrates the deviations at these times relative to the irradiance scale of F269.

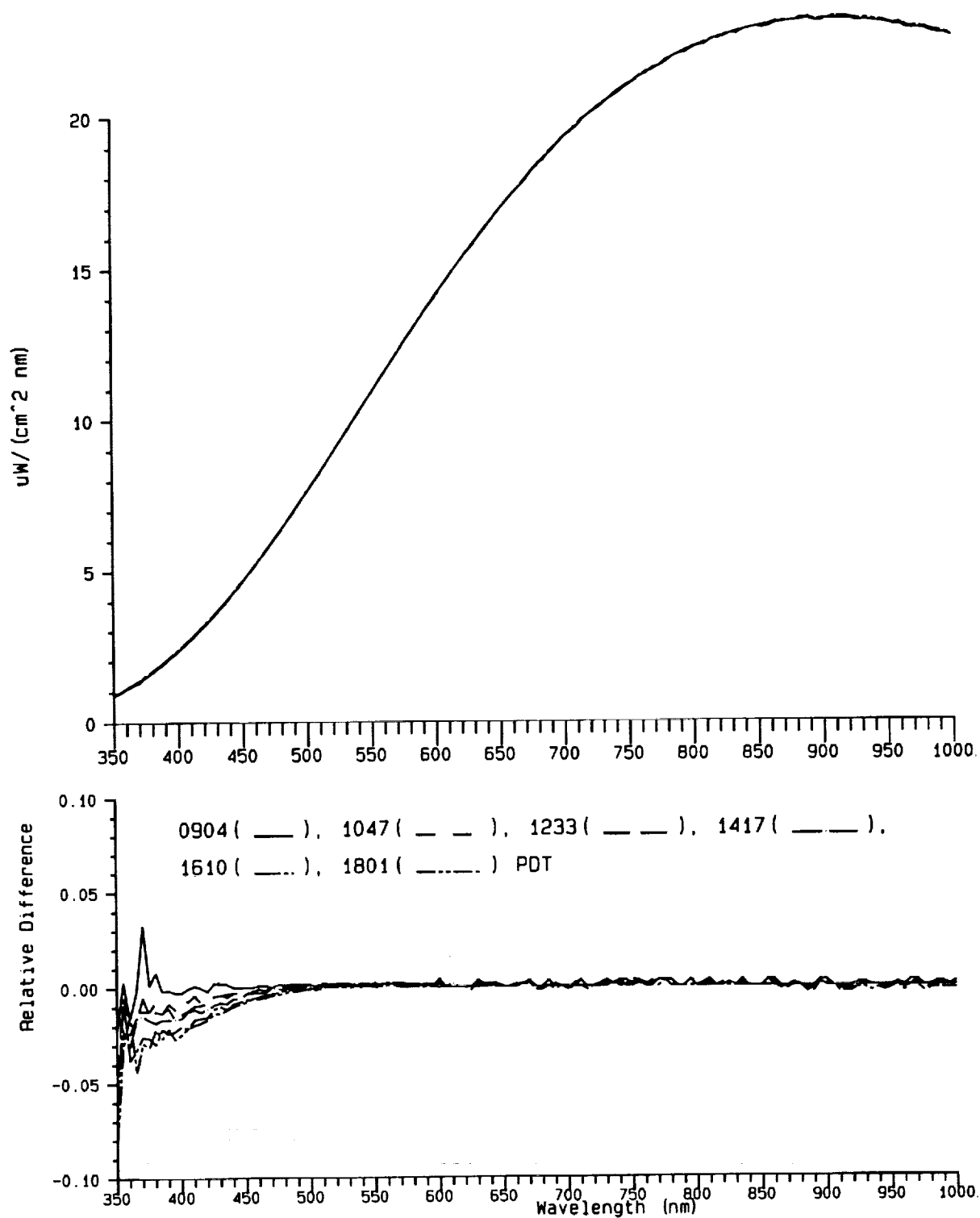


Fig. 4. Same as Fig. 3 for 23 June 1993 at 0904, 1047, 1233, 1417, 1610, and 1801 PDT.

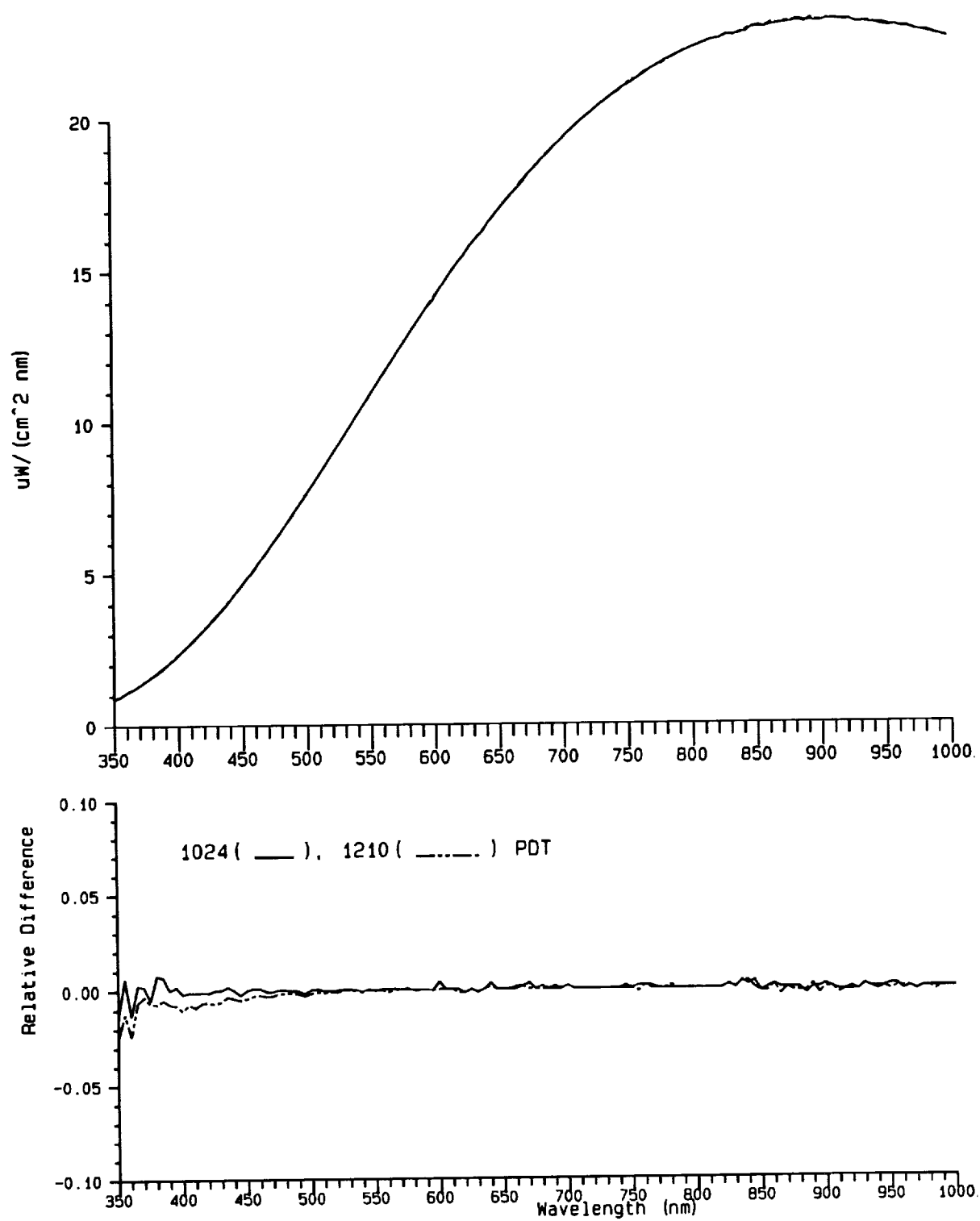


Fig. 5. Same as Fig. 3 for 24 June 1993 at 1024 and 1210 PDT.

Table 1. Scales of spectral irradiance for FEL lamps belonging to GSFC (F269, F268, F227, and F315) and UM (F12H and F12G) measured in units of $\mu\text{W cm}^{-2}\text{ nm}^{-1}$. The F269 scale is the average of the first check transfer on each of four days, and the F268 scale is the average of measurements on the first and fourth day. The standard deviation of these mean values for F269 is 0.2% or smaller for wavelengths greater than 400 nm. Lamp current in amperes is listed in each column head. F12G was measured at two lamp currents (by mistake); 7.907 A is correct. Scales were transferred from lamp F269 on 22–25 June 1993.

λ [nm]	F269 8.000 A	F268 8.001 A	F227 8.000 A	F315 8.000 A	F12H 8.000 A	F12G 7.907 A	F12G 8.001 A
350	0.8864	0.8507	0.8788	0.7047	0.7848	0.7641	0.8572
355	1.0002	0.9472	1.0122	0.8076	0.8840	0.8649	0.9661
360	1.1146	1.0765	1.1526	0.8955	1.0017	0.9844	1.0715
365	1.2329	1.1842	1.2726	0.9804	1.1013	1.0853	1.1963
370	1.3496	1.3109	1.3961	1.1013	1.2360	1.2069	1.3236
375	1.4998	1.4483	1.5265	1.2183	1.3505	1.3207	1.4558
380	1.6450	1.5857	1.6856	1.3309	1.4986	1.4659	1.6035
385	1.8159	1.7402	1.8612	1.4723	1.6346	1.6142	1.7528
390	1.9834	1.9104	2.0314	1.6064	1.7798	1.7452	1.9236
395	2.1590	2.0801	2.2147	1.7539	1.9466	1.9067	2.0876
400	2.3441	2.2632	2.3922	1.9060	2.1193	2.0583	2.2790
405	2.5428	2.4558	2.6054	2.0718	2.2926	2.2393	2.4666
410	2.7441	2.6538	2.8048	2.2501	2.4839	2.4188	2.6728
415	2.9587	2.8620	3.0276	2.4328	2.6801	2.6102	2.8708
420	3.1816	3.0777	3.2784	2.6246	2.8924	2.8088	3.0933
425	3.4068	3.3015	3.4815	2.7873	3.1036	3.0599	3.3247
430	3.6475	3.5193	3.7264	3.0242	3.3240	3.2565	3.5549
435	3.8917	3.7615	3.9898	3.2300	3.5460	3.4881	3.7908
440	4.1430	4.0070	4.2389	3.4462	3.7756	3.7071	4.0469
445	4.4027	4.2590	4.5035	3.6691	4.0225	3.9402	4.2937
450	4.6675	4.5090	4.7707	3.8986	4.2631	4.1882	4.5543
455	4.9390	4.7770	5.0612	4.1388	4.5141	4.4466	4.8243
460	5.2192	5.0519	5.3443	4.3801	4.7830	4.6990	5.1036
465	5.5072	5.3258	5.6340	4.6296	5.0440	4.9564	5.3741
470	5.7974	5.6136	5.9313	4.8825	5.3199	5.2218	5.6655
475	6.0899	5.9050	6.2332	5.1394	5.6052	5.5018	5.9605
480	6.3920	6.1961	6.5487	5.4109	5.8743	5.7842	6.2561
485	6.6993	6.4927	6.8527	5.6780	6.1647	6.0565	6.5608
490	7.0060	6.7985	7.1649	5.9446	6.4550	6.3469	6.8637
495	7.3235	7.1023	7.4861	6.2223	6.7398	6.6381	7.1696
500	7.6338	7.4087	7.8107	6.4986	7.0338	6.9308	7.4804
505	7.9547	7.7149	8.1331	6.7803	7.3438	7.2283	7.8040
510	8.2733	8.0362	8.4687	7.0710	7.6418	7.5329	8.1204
515	8.5989	8.3496	8.8006	7.3574	7.9492	7.8356	8.4380
520	8.9254	8.6700	9.1293	7.6510	8.2580	8.1310	8.7624
525	9.2503	8.9815	9.4760	7.9485	8.5590	8.4375	9.0808
530	9.5793	9.3089	9.8064	8.2407	8.8730	8.7515	9.3998
535	9.9084	9.6272	10.1415	8.5380	9.1725	9.0603	9.7119
540	10.2410	9.9508	10.4778	8.8318	9.4978	9.3622	10.0381
545	10.5636	10.2719	10.8191	9.1277	9.7987	9.6753	10.3589
550	10.8937	10.5987	11.1474	9.4279	10.1089	9.9835	10.6810
555	11.2246	10.9168	11.4889	9.7260	10.4288	10.3006	11.0156
560	11.5466	11.2383	11.8194	10.0194	10.7374	10.6002	11.3331
565	11.8725	11.5567	12.1569	10.3155	11.0462	10.9096	11.6505

Table 1. (cont.) Scales of spectral irradiance for FEL lamps belonging to GSFC (F269, F268, F227, and F315) and UM (F12H and F12G) measured in units of $\mu\text{W cm}^{-2}\text{ nm}^{-1}$. The F269 scale is the average of the first check transfer on each of four days, and the F268 scale is the average of measurements on the first and fourth day. The standard deviation of these mean values for F269 is 0.2% or smaller for wavelengths greater than 400 nm. Lamp current in amperes is listed in each column head. F12G was measured at two lamp currents (by mistake); 7.907 A is correct. Scales were transferred from lamp F269 on 22–25 June 1993.

λ [nm]	F269 8.000 A	F268 8.001 A	F227 8.000 A	F315 8.000 A	F12H 8.000 A	F12G 7.907 A	F12G 8.001 A
570	12.1975	11.8784	12.4886	10.6144	11.3611	11.2154	11.9732
575	12.5163	12.1842	12.8142	10.9157	11.6549	11.5135	12.2915
580	12.8361	12.5045	13.1364	11.1991	11.9642	11.8128	12.6074
585	13.1546	12.8118	13.4679	11.4845	12.2610	12.1246	12.9155
590	13.4707	13.1224	13.7799	11.7758	12.5677	12.4208	13.2312
595	13.7816	13.4243	14.0933	12.0527	12.8619	12.7029	13.5473
600	14.0720	13.7136	14.4096	12.3505	13.1651	13.0206	13.8335
605	14.3881	14.0266	14.7214	12.6412	13.4378	13.2813	14.1337
610	14.6990	14.2936	15.0118	12.8747	13.7051	13.5523	14.4375
615	14.9798	14.6231	15.3420	13.1667	14.0070	13.8756	14.7333
620	15.2759	14.9072	15.6166	13.4297	14.3014	14.0987	14.9984
625	15.5680	15.1668	15.9288	13.7122	14.5853	14.4081	15.3094
630	15.8429	15.4465	16.1860	13.9624	14.8316	14.6863	15.5515
635	16.1070	15.7217	16.4907	14.2537	15.0768	14.9560	15.8531
640	16.3666	15.9731	16.7794	14.4961	15.3702	15.2410	16.0983
645	16.6610	16.2449	17.0357	14.7222	15.5863	15.4583	16.3511
650	16.9314	16.4920	17.3029	14.9676	15.8665	15.7106	16.6386
655	17.1772	16.7470	17.5654	15.2091	16.1162	15.9588	16.9220
660	17.4181	16.9914	17.8369	15.4649	16.3616	16.2090	17.1200
665	17.6675	17.2430	18.0763	15.7280	16.5984	16.4926	17.4201
670	17.9121	17.4557	18.2992	15.9166	16.8479	16.6859	17.6368
675	18.1725	17.7038	18.5698	16.1719	17.0607	16.9526	17.8997
680	18.4000	17.9332	18.8229	16.3652	17.3048	17.1386	18.0899
685	18.6293	18.1784	19.0427	16.5911	17.4998	17.3608	18.3005
690	18.8606	18.3751	19.2290	16.7973	17.7438	17.5608	18.5624
695	19.0793	18.6235	19.4965	17.0375	17.9121	17.7986	18.7637
700	19.2926	18.8225	19.6858	17.2474	18.1366	18.0205	18.9719
705	19.4880	19.0257	19.9258	17.4199	18.3523	18.1747	19.2003
710	19.6847	19.1911	20.0684	17.6135	18.5435	18.4113	19.3927
715	19.8677	19.4113	20.3304	17.8205	18.7266	18.5735	19.5764
720	20.0682	19.5835	20.5267	17.9528	18.9143	18.7571	19.7535
725	20.2471	19.7638	20.6539	18.1303	19.0794	18.9272	19.9388
730	20.4206	19.9461	20.8523	18.3109	19.2194	19.0929	20.1346
735	20.5725	20.1010	21.0413	18.4985	19.4157	19.2613	20.2765
740	20.7189	20.2546	21.1970	18.6885	19.5554	19.4411	20.4282
745	20.8829	20.4056	21.3359	18.8333	19.7506	19.5963	20.5555
750	21.0490	20.5398	21.4703	18.9113	19.9296	19.7227	20.7367
755	21.1622	20.6893	21.6191	19.0907	20.0106	19.8741	20.8943
760	21.3248	20.8605	21.7956	19.2108	20.1343	20.0405	21.0292
765	21.4665	20.9237	21.9189	19.2968	20.2835	20.1509	21.1260
770	21.5864	21.0761	22.0373	19.4794	20.4260	20.2664	21.2826
775	21.7089	21.1973	22.1686	19.6274	20.5268	20.3965	21.3988
780	21.8260	21.3391	22.2772	19.7305	20.6376	20.4979	21.5423
785	21.9640	21.4404	22.3811	19.8093	20.7787	20.6434	21.6154
790	22.0622	21.5188	22.4970	19.9421	20.8608	20.7228	21.7152

Table 1. (cont.) Scales of spectral irradiance for FEL lamps belonging to GSFC (F269, F268, F227, and F315) and UM (F12H and F12G) measured in units of $\mu\text{W cm}^{-2}\text{nm}^{-1}$. The F269 scale is the average of the first check transfer on each of four days, and the F268 scale is the average of measurements on the first and fourth day. The standard deviation of these mean values for F269 is 0.2% or smaller for wavelengths greater than 400 nm. Lamp current in amperes is listed in each column head. F12G was measured at two lamp currents (by mistake); 7.907 A is correct. Scales were transferred from lamp F269 on 22–25 June 1993.

λ [nm]	F269 8.000 A	F268 8.001 A	F227 8.000 A	F315 8.000 A	F12H 8.000 A	F12G 7.907 A	F12G 8.001 A
795	22.1550	21.6643	22.6079	20.0718	20.9741	20.8689	21.8465
800	22.2700	21.6874	22.6387	20.1315	21.0947	20.9426	21.9180
805	22.3609	21.7857	22.8110	20.2223	21.1562	21.0102	22.0220
810	22.4180	21.9103	22.8666	20.3089	21.2589	21.1487	22.1399
815	22.5275	21.9939	22.9533	20.4373	21.3235	21.2115	22.2168
820	22.6035	22.0836	23.0337	20.4918	21.4348	21.2739	22.3078
825	22.6451	22.1402	23.1477	20.6197	21.4865	21.4097	22.3175
830	22.7511	22.1840	23.1373	20.6017	21.5484	21.3941	22.4230
835	22.7731	22.2259	23.2799	20.7374	21.6070	21.5320	22.4840
840	22.8303	22.3433	23.3152	20.7870	21.6694	21.5610	22.4631
845	22.9029	22.3687	23.3474	20.8054	21.7275	21.6301	22.5966
850	22.9510	22.4006	23.3512	20.8521	21.7461	21.6331	22.6081
855	22.9851	22.4604	23.4113	20.9643	21.8391	21.6790	22.6940
860	22.9959	22.5068	23.5040	21.0541	21.8642	21.7431	22.7553
865	23.0694	22.5491	23.4940	20.9914	21.9438	21.7797	22.7762
870	23.0911	22.5690	23.5555	21.1034	21.9169	21.8465	22.8115
875	23.1364	22.5857	23.5934	21.1013	21.9918	21.8489	22.7892
880	23.1501	22.6085	23.5724	21.1203	21.9686	21.8562	22.8344
885	23.1776	22.6707	23.5479	21.1876	22.0401	21.8422	22.8932
890	23.1835	22.6585	23.6272	21.1959	22.0634	21.8767	22.8955
895	23.1600	22.6591	23.6508	21.2282	22.0311	21.9482	22.8586
900	23.1760	22.6735	23.6356	21.2503	22.0529	21.9457	22.8697
905	23.2123	22.6898	23.6484	21.2668	22.0685	21.9376	22.8759
910	23.2026	22.6853	23.6262	21.2289	22.0461	21.9088	22.9120
915	23.2058	22.6689	23.6007	21.2340	22.0201	21.8914	22.8772
920	23.1891	22.6730	23.6387	21.2803	22.0687	21.9485	22.8715
925	23.1689	22.6481	23.5737	21.2422	22.0398	21.8898	22.8446
930	23.1291	22.6330	23.6240	21.2875	22.0251	21.9366	22.8293
935	23.1428	22.6128	23.5736	21.2650	22.0096	21.9153	22.8248
940	23.1207	22.6013	23.5651	21.2333	22.0274	21.8940	22.8048
945	23.0954	22.5829	23.5254	21.2215	21.9899	21.8705	22.7628
950	23.0426	22.5360	23.4995	21.2060	21.9981	21.8545	22.7814
955	23.0273	22.4938	23.4535	21.1531	21.9277	21.8232	22.7155
960	23.0176	22.5117	23.4551	21.1502	21.9484	21.7959	22.7441
965	22.9555	22.4351	23.3728	21.1023	21.8336	21.7367	22.6372
970	22.9066	22.3967	23.2697	21.0374	21.8190	21.7139	22.6430
975	22.8892	22.3699	23.3029	21.0967	21.7828	21.7172	22.5781
980	22.8438	22.3415	23.2655	21.0163	21.7862	21.6489	22.5618
985	22.7867	22.2729	23.2093	20.9733	21.6876	21.6370	22.4889
990	22.7360	22.2082	23.1514	20.9729	21.7073	21.5636	22.4482
995	22.6923	22.1662	23.0730	20.8647	21.6225	21.5500	22.3866
1000	22.6271	22.1118	23.0312	20.8228	21.6171	21.4538	22.3396

Table 2. Scales of spectral irradiance for FEL lamps belonging to SDSU CHORS (90572, 91348, 91349, 91533, and 91534) measured in units of $\mu\text{W cm}^{-2}\text{ nm}^{-1}$; scales were transferred from lamp F269 on 22–25 June 1993. The scale under “91349B” is for lamp 91349 with a circular baffle limiting the detector field-of-view to the lamp envelope and filament, and blocking the base. The lamp current, in amperes, is listed in each column head.

λ [nm]	90572 7.108 A	91348 7.656 A	91349 7.656 A	91533 8.000 A	91534 8.000 A	91349B 7.656 A
350	0.2480	0.6107	0.5572	0.8757	0.7686	0.5820
355	0.3363	0.7245	0.6891	0.9839	0.8934	0.6890
360	0.3559	0.8066	0.7663	1.0901	0.9953	0.7575
365	0.3892	0.8845	0.8437	1.2149	1.1098	0.8555
370	0.4328	0.9810	0.9435	1.3520	1.2271	0.9380
375	0.4704	1.0895	1.0392	1.4818	1.3571	1.0193
380	0.4980	1.1824	1.1497	1.6133	1.4933	1.1269
385	0.4455	1.0071	0.9619	1.7717	1.6404	0.9687
390	0.4809	1.4300	1.3731	1.9535	1.7813	1.3435
395	0.5371	1.5630	1.4882	2.1256	1.9555	1.4723
400	0.7692	1.7096	1.6252	2.2993	2.1234	1.6060
405	0.8206	1.8539	1.7698	2.5038	2.3044	1.7462
410	0.9071	2.0130	1.9147	2.7084	2.4943	1.8978
415	0.9907	2.1845	2.0760	2.9132	2.6929	2.0563
420	1.0786	2.3547	2.2446	3.1361	2.8987	2.2177
425	1.1576	2.5068	2.3873	3.3539	3.1095	2.3610
430	1.2499	2.7223	2.5620	3.5952	3.3291	2.5398
435	1.3527	2.9050	2.7715	3.8298	3.5596	2.7512
440	1.4596	3.1069	2.9651	4.0800	3.7954	2.9297
445	1.5637	3.3129	3.1654	4.3334	4.0391	3.1218
450	1.6781	3.5232	3.3623	4.6015	4.2877	3.3282
455	1.8112	3.7438	3.5758	4.8751	4.5447	3.5359
460	1.9330	3.9671	3.7934	5.1452	4.8136	3.7521
465	2.0595	4.2016	4.0142	5.4271	5.0788	3.9766
470	2.1928	4.4330	4.2394	5.7161	5.3586	4.1946
475	2.3283	4.6741	4.4693	6.0019	5.6384	4.4257
480	2.4729	4.9257	4.7085	6.2999	5.9234	4.6616
485	2.6149	5.1773	4.9501	6.6017	6.2165	4.9007
490	2.7599	5.4268	5.1905	6.9122	6.5042	5.1376
495	2.9151	5.6909	5.4433	7.2200	6.8067	5.3874
500	3.0669	5.9496	5.6944	7.5308	7.1051	5.6372
505	3.2266	6.2187	5.9550	7.8441	7.4152	5.8907
510	3.3826	6.4881	6.2202	8.1588	7.7189	6.1442
515	3.5512	6.7554	6.4723	8.4787	8.0279	6.4033
520	3.7164	7.0322	6.7401	8.7994	8.3387	6.6662
525	3.8855	7.3044	7.0010	9.1263	8.6589	6.9334
530	4.0551	7.5781	7.2718	9.4454	8.9745	7.1940
535	4.2288	7.8616	7.5388	9.7616	9.2852	7.4623
540	4.4061	8.1422	7.8140	10.0917	9.6085	7.7333
545	4.5862	8.4210	8.0878	10.4135	9.9327	8.0025
550	4.7618	8.7012	8.3632	10.7380	10.2435	8.2729
555	4.9464	8.9926	8.6394	11.0629	10.5642	8.5486
560	5.1256	9.2695	8.9100	11.3916	10.8752	8.8160
565	5.3062	9.5510	9.1810	11.7080	11.1909	9.0850
570	5.4910	9.8318	9.4501	12.0321	11.5131	9.3547
575	5.6778	10.1053	9.7225	12.3466	11.8177	9.6278
580	5.8554	10.3876	10.0035	12.6518	12.1183	9.9004

Table 2. (cont.) Scales of spectral irradiance for FEL lamps belonging to SDSU CHORS (90572, 91348, 91349, 91533, and 91534) measured in units of $\mu\text{W cm}^{-2}\text{nm}^{-1}$; scales were transferred from lamp F269 on 22–25 June 1993. The scale under "91349B" is for lamp 91349 with a circular baffle limiting the detector field-of-view to the lamp envelope and filament, and blocking the base. The lamp current, in amperes, is listed in each column head.

λ [nm]	90572 7.108 A	91348 7.656 A	91349 7.656 A	91533 8.000 A	91534 8.000 A	91349B 7.656 A
585	6.0389	10.6608	10.2688	12.9725	12.4366	10.1605
590	6.2242	10.9410	10.5328	13.2841	12.7415	10.4269
595	6.4096	11.2171	10.8002	13.5854	13.0390	10.6917
600	6.5841	11.5106	11.1004	13.8967	13.3282	10.9946
605	6.7778	11.7781	11.3498	14.1873	13.6519	11.2070
610	6.9624	12.0312	11.5866	14.5098	13.9281	11.4673
615	7.1540	12.2950	11.8800	14.7852	14.2145	11.7082
620	7.3211	12.5460	12.0813	15.0242	14.4821	11.9434
625	7.4974	12.8158	12.3563	15.3551	14.7550	12.2172
630	7.6933	13.0845	12.6114	15.5955	15.0562	12.4420
635	7.8752	13.3080	12.8905	15.8718	15.3299	12.6782
640	8.0446	13.5285	13.0772	16.1433	15.5722	12.9262
645	8.2200	13.7777	13.2969	16.4301	15.8490	13.1711
650	8.3965	14.0563	13.5771	16.6652	16.1327	13.4151
655	8.5711	14.2897	13.8062	16.9220	16.3848	13.6136
660	8.7361	14.4654	14.0319	17.1742	16.6054	13.8376
665	8.9155	14.7358	14.2428	17.4201	16.8723	14.0742
670	9.0772	14.9260	14.4838	17.6565	17.0970	14.2939
675	9.2488	15.2035	14.6945	17.8997	17.3404	14.5102
680	9.4022	15.3644	14.9125	18.1250	17.5819	14.7032
685	9.5677	15.6126	15.0979	18.3577	17.7858	14.9377
690	9.7492	15.8248	15.2907	18.5768	18.0544	15.1462
695	9.8869	16.0328	15.5042	18.7637	18.2351	15.3161
700	10.0553	16.2154	15.7321	19.0096	18.4496	15.5588
705	10.2028	16.4141	15.9295	19.2239	18.6715	15.7050
710	10.3674	16.6171	16.0796	19.4524	18.8966	15.8951
715	10.4989	16.7934	16.2832	19.5764	19.0728	16.0443
720	10.6449	16.9454	16.4612	19.7535	19.2370	16.2537
725	10.7740	17.1238	16.6241	19.9468	19.4063	16.4202
730	10.9062	17.2959	16.7738	20.0945	19.5974	16.5740
735	11.0596	17.4709	16.9608	20.2765	19.7664	16.7305
740	11.1952	17.5863	17.1013	20.4194	19.9233	16.8815
745	11.3061	17.7614	17.2307	20.5633	20.0566	17.0550
750	11.4394	17.8903	17.3828	20.6967	20.2032	17.2007
755	11.5795	18.0719	17.5601	20.8943	20.3893	17.3190
760	11.6907	18.2167	17.7054	21.0534	20.5347	17.4614
765	11.8040	18.3392	17.8352	21.1511	20.6584	17.6118
770	11.9376	18.4540	17.9455	21.2826	20.8214	17.7144
775	12.0478	18.5814	18.0783	21.3988	20.9293	17.8445
780	12.1413	18.7105	18.1983	21.5102	21.0322	17.9714
785	12.2476	18.8263	18.3382	21.6154	21.1273	18.0717
790	12.3670	18.9385	18.4401	21.7152	21.2880	18.2034
795	12.4661	19.0165	18.5282	21.8101	21.3739	18.3327
800	12.5518	19.1626	18.6446	21.9001	21.4561	18.3617
805	12.6486	19.2740	18.7470	21.9844	21.5326	18.4589
810	12.7289	19.3329	18.7893	22.0547	21.6637	18.5785
815	12.8290	19.4203	18.9542	22.2168	21.7507	18.6568

Table 2. (cont.) Scales of spectral irradiance for FEL lamps belonging to SDSU CHORS (90572, 91348, 91349, 91533, and 91534) measured in units of $\mu\text{W cm}^{-2}\text{ nm}^{-1}$; scales were transferred from lamp F269 on 22–25 June 1993. The scale under “91349B” is for lamp 91349 with a circular baffle limiting the detector field-of-view to the lamp envelope and filament, and blocking the base. The lamp current, in amperes, is listed in each column head.

λ [nm]	90572 7.108 A	91348 7.656 A	91349 7.656 A	91533 8.000 A	91534 8.000 A	91349B 7.656 A
820	12.9107	19.5034	18.9932	22.2111	21.8186	18.7515
825	13.0017	19.6102	19.0480	22.3175	21.9218	18.8495
830	13.0682	19.6798	19.1630	22.3435	21.9857	18.9377
835	13.1428	19.7211	19.2352	22.4144	22.0252	19.0289
840	13.2080	19.7644	19.2881	22.4631	22.1059	19.0236
845	13.2814	19.8312	19.3572	22.5176	22.1225	19.1135
850	13.3415	19.9045	19.4343	22.5689	22.1771	19.1730
855	13.4391	20.0179	19.4569	22.6348	22.2640	19.2541
860	13.4588	19.9815	19.5221	22.6610	22.2782	19.3049
865	13.5392	20.1115	19.5908	22.7678	22.3817	19.3516
870	13.6075	20.1118	19.6192	22.7742	22.4388	19.4188
875	13.6329	20.1345	19.6220	22.7703	22.4042	19.4506
880	13.7042	20.2010	19.6960	22.7983	22.4736	19.4967
885	13.8259	20.2159	19.7279	22.7795	22.4522	19.5031
890	13.8478	20.2739	19.7765	22.8427	22.5278	19.5707
895	13.9289	20.2728	19.7901	22.8241	22.5483	19.5647
900	13.9532	20.2832	19.8068	22.8961	22.5479	19.6131
905	13.9947	20.3192	19.8482	22.8759	22.5395	19.6567
910	14.0488	20.2993	19.8253	22.8454	22.5790	19.6464
915	14.0580	20.3203	19.8510	22.8186	22.5618	19.6560
920	14.0646	20.3368	19.8716	22.8623	22.5605	19.6460
925	14.0974	20.3418	19.8944	22.8201	22.5531	19.6718
930	14.1638	20.3284	19.8663	22.8368	22.5696	19.6748
935	14.1750	20.3185	19.8475	22.8248	22.5313	19.6604
940	14.1838	20.3288	19.8681	22.7724	22.4809	19.6885
945	14.1786	20.3419	19.8394	22.7781	22.5178	19.6364
950	14.2103	20.3051	19.8488	22.7088	22.4408	19.6301
955	14.2464	20.2864	19.8268	22.7155	22.4529	19.6395
960	14.2317	20.2472	19.8421	22.6705	22.4315	19.6373
965	14.2655	20.2262	19.8243	22.6038	22.3694	19.5664
970	14.2477	20.2182	19.8111	22.5850	22.3398	19.5497
975	14.2356	20.2314	19.7320	22.5435	22.3360	19.5282
980	14.2734	20.1884	19.7749	22.4492	22.2302	19.5402
985	14.2557	20.1509	19.7105	22.4993	22.2030	19.4879
990	14.2707	20.1034	19.6514	22.4400	22.1359	19.4220
995	14.2822	20.0775	19.6868	22.3866	22.1574	19.3607
1000	14.2415	20.0476	19.6036	22.3203	22.0828	19.3242

Table 3. Scales of spectral irradiance for FEL lamps belonging to BSI (91357, F321, and F310), and Satlantic (91615, 91604, and 91591) both measured in units of $\mu\text{W cm}^{-2}\text{ nm}^{-1}$; scales were transferred from lamp F269 on 22–25 June 1993. The lamp current, in amperes, is listed in each column head.

λ [nm]	91357 7.901 A	F321 7.901 A	F310 7.901 A	91615 8.001 A	91604 8.001 A	91591 6.947 A
350	0.7028	0.7261	0.6887	0.9174	0.2548	0.9123
355	0.8096	0.8605	0.7883	0.9966	0.3125	1.0083
360	0.9041	0.9417	0.8762	1.1050	0.3556	1.1279
365	1.0025	1.0631	0.9719	1.2331	0.3879	1.2702
370	1.1069	1.1673	1.0871	1.3835	0.4349	1.4068
375	1.2262	1.2818	1.1942	1.5323	0.4675	1.5433
380	1.3333	1.4172	1.3000	1.6772	0.5010	1.7032
385	1.4912	1.5529	1.4359	1.8459	0.4450	1.8740
390	1.6279	1.7118	1.5795	2.0096	0.4848	2.0348
395	1.7729	1.8567	1.7196	2.1857	0.5402	2.2207
400	1.9218	2.0224	1.8782	2.3702	0.7600	2.4130
405	2.0932	2.2048	2.0403	2.5740	0.8329	2.6187
410	2.2666	2.3828	2.2165	2.7867	0.9084	2.8253
415	2.4516	2.5778	2.3952	3.0020	0.9912	3.0484
420	2.6364	2.7750	2.5851	3.2271	1.0810	3.3075
425	2.8042	2.9462	2.7539	3.4658	1.1591	3.5001
430	3.0824	3.1986	2.9796	3.7052	1.2560	3.7646
435	3.2673	3.4054	3.1815	3.9509	1.3557	4.0116
440	3.4954	3.6392	3.3819	4.2092	1.4623	4.2770
445	3.7193	3.8730	3.6092	4.4665	1.5691	4.5388
450	3.9595	4.1120	3.8490	4.7389	1.6814	4.8131
455	4.2097	4.3661	4.0930	5.0141	1.8165	5.0890
460	4.4510	4.6130	4.3314	5.3062	1.9392	5.3842
465	4.7074	4.8835	4.5786	5.5930	2.0638	5.6765
470	4.9673	5.1462	4.8324	5.8921	2.1997	5.9798
475	5.2317	5.4180	5.0945	6.1902	2.3346	6.2913
480	5.5039	5.6956	5.3535	6.4963	2.4793	6.5949
485	5.7807	5.9792	5.6274	6.8115	2.6202	6.9164
490	6.0549	6.2610	5.8958	7.1243	2.7665	7.2330
495	6.3363	6.5466	6.1732	7.4314	2.9214	7.5583
500	6.6256	6.8388	6.4525	7.7505	3.0745	7.8802
505	6.9128	7.1355	6.7356	8.0817	3.2347	8.2131
510	7.2113	7.4347	6.9934	8.4044	3.3944	8.5490
515	7.5052	7.7352	7.3056	8.7302	3.5581	8.8792
520	7.7997	8.0402	7.6035	9.0749	3.7266	9.2184
525	8.0936	8.3424	7.8863	9.3942	3.8931	9.5566
530	8.3940	8.6485	8.1836	9.7214	4.0648	9.8921
535	8.6960	8.9585	8.4835	10.0517	4.2361	10.2304
540	9.0025	9.2692	8.7773	10.3897	4.4173	10.5770
545	9.2976	9.5755	9.0705	10.7152	4.5947	10.9133
550	9.6005	9.8827	9.3688	11.0449	4.7701	11.2527
555	9.9062	10.1955	9.6813	11.3823	4.9478	11.5926
560	10.2045	10.5038	9.9731	11.7058	5.1328	12.0075
565	10.5096	10.8086	10.2705	12.0405	5.3159	12.2952
570	10.8069	11.1189	10.5679	12.3762	5.5005	12.6272
575	11.1085	11.4175	10.8550	12.7042	5.6822	12.9849

Table 3. (cont.) Scales of spectral irradiance for FEL lamps belonging to BSI (91357, F321, and F310), and Satlantic (91615, 91604, and 91591) both measured in units of $\mu\text{W cm}^{-2}\text{ nm}^{-1}$; scales were transferred from lamp F269 on 22–25 June 1993. The lamp current, in amperes, is listed in each column head.

λ [nm]	91357 7.901 A	F321 7.901 A	F310 7.901 A	91615 8.001 A	91604 8.001 A	91591 6.947 A
580	11.4106	11.7251	11.0920	13.0117	5.8680	13.2847
585	11.7113	12.0332	11.3796	13.3234	6.0566	13.6465
590	12.0014	12.3294	11.6677	13.6682	6.2392	13.9584
595	12.2963	12.6211	11.9576	13.9610	6.4238	14.2349
600	12.6336	12.9156	12.2538	14.2971	6.6054	14.5785
605	12.8591	13.1918	12.5276	14.5620	6.7858	14.8833
610	13.1770	13.4920	12.7707	14.8626	6.9769	15.1832
615	13.4545	13.8127	13.0732	15.2002	7.1617	15.5115
620	13.7284	14.0910	13.3204	15.4373	7.3314	15.7470
625	14.0061	14.3639	13.5866	15.7231	7.5150	16.0593
630	14.2566	14.6154	13.8677	16.0304	7.6961	16.3416
635	14.4564	14.8740	14.1361	16.2763	7.8763	16.6351
640	14.7698	15.1377	14.3718	16.5763	8.0484	16.9108
645	15.0273	15.3977	14.6339	16.8326	8.2249	17.2086
650	15.2763	15.6769	14.8549	17.0911	8.3991	17.4638
655	15.5686	15.9402	15.0955	17.3517	8.5819	17.7278
660	15.7601	16.1406	15.3322	17.6076	8.7469	17.9869
665	16.0156	16.3939	15.6123	17.8583	8.9209	18.2418
670	16.2425	16.6248	15.8184	18.1337	9.0945	18.5489
675	16.4910	16.8774	16.0538	18.3472	9.2575	18.7947
680	16.7143	17.1110	16.2758	18.5555	9.4192	19.0081
685	16.9227	17.3242	16.4704	18.8152	9.5763	19.2155
690	17.1466	17.5474	16.7192	19.0199	9.7519	19.4908
695	17.3488	17.7317	16.9137	19.2335	9.8986	19.6739
700	17.5672	17.9556	17.1145	19.4419	10.0445	19.9118
705	17.8026	18.1672	17.3009	19.6624	10.2209	20.1246
710	17.9710	18.3415	17.5381	19.8847	10.3715	20.3479
715	18.1867	18.5656	17.6880	20.0800	10.5058	20.5206
720	18.3277	18.7486	17.8814	20.2376	10.6417	20.7218
725	18.5173	18.9184	17.9989	20.4213	10.7946	20.8885
730	18.6848	19.0711	18.1860	20.5922	10.9204	21.0498
735	18.8692	19.2850	18.3636	20.7866	11.0628	21.2329
740	19.0226	19.4327	18.5473	20.9069	11.1872	21.4022
745	19.1609	19.5679	18.6753	21.0706	11.3200	21.5707
750	19.3610	19.7314	18.8025	21.2373	11.4319	21.7228
755	19.5003	19.8802	19.0006	21.3678	11.5771	21.9043
760	19.6178	20.0024	19.1205	21.4846	11.6877	22.0041
765	19.7306	20.1201	19.2268	21.6444	11.8105	22.1628
770	19.8897	20.2785	19.4047	21.7438	11.9360	22.3369
775	20.0181	20.4555	19.5206	21.8684	12.0444	22.4051
780	20.1385	20.5152	19.5982	21.9541	12.1311	22.5004
785	20.2150	20.6347	19.7327	22.1035	12.2476	22.6264
790	20.3569	20.7855	19.8640	22.2136	12.3527	22.7475
795	20.4817	20.9031	19.9926	22.3190	12.4681	22.9006
800	20.5619	21.0073	20.0504	22.3440	12.5444	22.9359
805	20.6912	21.0605	20.1021	22.4738	12.6372	23.0384

Table 3. (cont.) Scales of spectral irradiance for FEL lamps belonging to BSI (91357, F321, and F310), and Satlantic (91615, 91604, and 91591) both measured in units of $\mu\text{W cm}^{-2}\text{ nm}^{-1}$; scales were transferred from lamp F269 on 22–25 June 1993. The lamp current, in amperes, is listed in each column head.

λ [nm]	91357 7.901 A	F321 7.901 A	F310 7.901 A	91615 8.001 A	91604 8.001 A	91591 6.947 A
810	20.7410	21.1852	20.2010	22.5996	12.7477	23.1358
815	20.8522	21.2810	20.3524	22.6440	12.8174	23.2266
820	20.9346	21.3113	20.4059	22.6820	12.8911	23.3099
825	21.0382	21.4267	20.4973	22.7924	12.9908	23.3463
830	21.0498	21.4316	20.5544	22.8206	13.0602	23.4170
835	21.1874	21.5698	20.6023	22.9424	13.1136	23.4803
840	21.2174	21.6072	20.6375	22.9394	13.1921	23.4950
845	21.2468	21.6829	20.7398	22.9916	13.2696	23.5447
850	21.3385	21.7237	20.7665	23.0391	13.3376	23.5876
855	21.3909	21.8023	20.8845	23.1407	13.3884	23.6650
860	21.4590	21.8350	20.9002	23.1498	13.4571	23.6767
865	21.4846	21.8642	20.9370	23.2302	13.5408	23.7599
870	21.5387	21.9501	21.0224	23.2588	13.5937	23.7806
875	21.5823	22.0162	21.0131	23.2375	13.6239	23.7781
880	21.6030	22.0011	21.0668	23.2312	13.6826	23.8083
885	21.6448	22.0371	21.0608	23.3111	13.8485	23.8355
890	21.6455	22.0671	21.1286	23.3237	13.8579	23.8404
895	21.6472	22.0275	21.1692	23.3068	13.8600	23.8240
900	21.6724	22.0826	21.1779	23.2868	13.9346	23.8401
905	21.6603	22.0652	21.1938	23.2796	13.9610	23.8515
910	21.7397	22.0742	21.1803	23.3116	13.9870	23.8444
915	21.7021	22.1181	21.1835	23.2727	14.0428	23.8002
920	21.6858	22.0801	21.2109	23.2956	14.0887	23.8526
925	21.7239	22.0898	21.1811	23.2177	14.1127	23.8030
930	21.7335	22.1250	21.2291	23.2753	14.1179	23.8034
935	21.7121	22.0718	21.1945	23.2161	14.1514	23.7704
940	21.6995	22.0243	21.1852	23.1936	14.1559	23.7442
945	21.6677	22.0593	21.1511	23.1686	14.1875	23.7543
950	21.6591	22.0124	21.1291	23.1404	14.2302	23.6953
955	21.6202	22.0080	21.1070	23.1094	14.2136	23.6346
960	21.6379	21.9637	21.1323	23.0757	14.2565	23.6724
965	21.6240	21.9609	21.0299	23.0056	14.1985	23.5749
970	21.5668	21.9080	21.0421	23.0004	14.2691	23.5780
975	21.5218	21.8537	21.0222	22.9238	14.2453	23.5116
980	21.4226	21.8392	20.9559	22.9057	14.2263	23.4611
985	21.4855	21.7668	20.9695	22.8409	14.2777	23.4263
990	21.3925	21.7477	20.8693	22.8186	14.2987	23.3743
995	21.3351	21.6632	20.8585	22.7686	14.2877	23.3034
1000	21.3267	21.6841	20.8164	22.6764	14.2470	23.2701

Table 4. Scales of spectral irradiance for FEL lamps belonging to UCSB (F303, F219, F304, and F305) and NOAA (F307 and F308) both measured in units of $\mu\text{W cm}^{-2}\text{ nm}^{-1}$; scales were transferred from lamp F269 on 22–25 June 1993. The lamp current, in amperes, is listed in each column head.

λ [nm]	F303 8.001 A	F219 8.000 A	F304 8.000 A	F305 8.000 A	F307 8.000 A	F308 8.000 A
350	0.8754	0.8935	0.8467	0.7570	0.8470	0.8771
355	0.9844	0.9851	0.9619	0.8765	0.9626	0.9969
360	1.0970	1.0985	1.0821	0.9781	1.0765	1.1103
365	1.2382	1.2308	1.2025	1.0937	1.1849	1.2314
370	1.3564	1.3596	1.3191	1.1834	1.3191	1.3780
375	1.5020	1.4900	1.4484	1.3309	1.4514	1.5033
380	1.6469	1.6223	1.5901	1.4370	1.6021	1.6650
385	1.8044	1.8096	1.7537	1.5844	1.7491	1.8238
390	1.9585	1.9549	1.9115	1.7319	1.9106	1.9974
395	2.1510	2.1448	2.0983	1.8975	2.0828	2.1719
400	2.3353	2.3259	2.2758	2.0665	2.2630	2.3683
405	2.5330	2.5254	2.4597	2.2425	2.4545	2.5599
410	2.7348	2.7322	2.6672	2.4280	2.6555	2.7736
415	2.9493	2.9506	2.8838	2.6298	2.8618	2.9807
420	3.1770	3.1711	3.0960	2.8297	3.0753	3.2081
425	3.4048	3.3970	3.3244	3.0299	3.2999	3.4391
430	3.6315	3.6350	3.5473	3.2561	3.5320	3.6808
435	3.8770	3.8770	3.7874	3.4734	3.7731	3.9269
440	4.1252	4.1310	4.0321	3.7089	4.0145	4.1885
445	4.3848	4.3902	4.2878	3.9450	4.2624	4.4340
450	4.6450	4.6550	4.5444	4.1825	4.5217	4.7050
455	4.9202	4.9355	4.8194	4.4357	4.7913	4.9801
460	5.2035	5.2146	5.0943	4.6977	5.0702	5.2684
465	5.4893	5.4955	5.3715	4.9634	5.3476	5.5518
470	5.7853	5.7993	5.6651	5.2321	5.6322	5.8417
475	6.0746	6.0928	5.9617	5.5146	5.9228	6.1458
480	6.3734	6.3910	6.2538	5.7919	6.2150	6.4402
485	6.6828	6.7021	6.5587	6.0753	6.5159	6.7558
490	6.9927	7.0116	6.8596	6.3626	6.8197	7.0669
495	7.3040	7.3286	7.1742	6.6618	7.1282	7.3821
500	7.6294	7.6513	7.4916	6.9513	7.4406	7.6997
505	7.9419	7.9704	7.8003	7.2512	7.7502	8.0255
510	8.2642	8.2996	8.1256	7.5546	8.0654	8.3472
515	8.5805	8.6233	8.4480	7.8657	8.3829	8.6697
520	8.9014	8.9399	8.7637	8.1640	8.7063	9.0005
525	9.2356	9.2759	9.0904	8.4746	9.0207	9.3326
530	9.5637	9.6121	9.4203	8.7915	9.3541	9.6643
535	9.8869	9.9417	9.7486	9.1060	9.6765	9.9934
540	10.2114	10.2693	10.0709	9.4091	9.9902	10.3278
545	10.5410	10.5981	10.4025	9.7231	10.3204	10.6605
550	10.8750	10.9356	10.7364	10.0330	10.6433	10.9917
555	11.2087	11.2695	11.0662	10.3519	10.9716	11.3316
560	11.5295	11.5897	11.3824	10.6607	11.2888	11.6513
565	11.8543	11.9201	11.7018	10.9734	11.6177	11.9757
570	12.1690	12.2372	12.0329	11.2802	11.9355	12.3091
575	12.4889	12.5643	12.3495	11.5812	12.2430	12.6225

Table 4. (cont.) Scales of spectral irradiance for FEL lamps belonging to UCSB (F303, F219, F304, and F305) and NOAA (F307 and F308) both measured in units of $\mu\text{W cm}^{-2}\text{ nm}^{-1}$; scales were transferred from lamp F269 on 22–25 June 1993. The lamp current, in amperes, is listed in each column head.

λ [nm]	F303 8.001 A	F219 8.000 A	F304 8.000 A	F305 8.000 A	F307 8.000 A	F308 8.000 A
580	12.8034	12.8959	12.6604	11.8992	12.5616	12.9466
585	13.1254	13.2086	12.9846	12.2080	12.8760	13.2730
590	13.4465	13.5450	13.3038	12.5110	13.1803	13.5933
595	13.7622	13.8527	13.6082	12.8117	13.4942	13.8967
600	14.0225	14.1564	13.9026	13.0848	13.8261	14.2193
605	14.3881	14.4685	14.2141	13.3969	14.1337	14.5353
610	14.6337	14.7519	14.4894	13.6757	14.3851	14.8036
615	14.9598	15.0701	14.8103	13.9789	14.7074	15.1483
620	15.2435	15.3537	15.0881	14.2523	14.9726	15.3856
625	15.5027	15.6453	15.3858	14.5296	15.2576	15.6714
630	15.8103	15.9469	15.6798	14.7879	15.4997	15.9592
635	16.0605	16.1911	15.9432	15.0684	15.7942	16.2631
640	16.3661	16.4713	16.2019	15.3277	16.0652	16.5105
645	16.6279	16.7604	16.4823	15.5687	16.3050	16.7731
650	16.8652	17.0390	16.7452	15.8639	16.6119	17.0379
655	17.1227	17.2977	17.0014	16.1122	16.8682	17.3517
660	17.3296	17.5264	17.2274	16.3579	17.1270	17.5805
665	17.6260	17.7974	17.5159	16.6306	17.3653	17.8309
670	17.8702	18.0434	17.7589	16.8086	17.5670	18.0637
675	18.1094	18.2919	18.0113	17.0855	17.8438	18.3193
680	18.3432	18.5702	18.2157	17.2941	18.0827	18.5345
685	18.5497	18.7793	18.4854	17.5314	18.2862	18.7580
690	18.7952	18.9768	18.6785	17.7693	18.5408	19.0343
695	18.9901	19.2259	18.8946	17.9740	18.7343	19.2041
700	19.2250	19.4045	19.0905	18.1785	18.9719	19.4492
705	19.4649	19.6473	19.3361	18.4170	19.1397	19.6545
710	19.6220	19.8694	19.5451	18.6027	19.3459	19.8383
715	19.8205	20.0180	19.7338	18.8181	19.5450	20.0170
720	20.0030	20.2299	19.9303	18.9827	19.6889	20.2054
725	20.1473	20.4150	20.0719	19.1604	19.8637	20.3967
730	20.3548	20.5846	20.2483	19.3215	20.0773	20.5922
735	20.5158	20.7721	20.4360	19.5237	20.2446	20.7547
740	20.6945	20.8838	20.5684	19.6851	20.3572	20.9225
745	20.8120	21.0864	20.7574	19.8016	20.5551	21.0467
750	20.9625	21.2219	20.9075	19.9958	20.7206	21.2292
755	21.0831	21.3680	21.0198	20.1334	20.8233	21.3678
760	21.2762	21.5250	21.1882	20.2738	20.9732	21.4766
765	21.3768	21.6613	21.3204	20.3947	21.1260	21.6444
770	21.5037	21.7679	21.4627	20.5303	21.2826	21.8097
775	21.5994	21.8685	21.5657	20.6574	21.3988	21.9020
780	21.7835	22.0061	21.6801	20.7713	21.5084	22.0396
785	21.8938	22.1565	21.7887	20.9309	21.5805	22.1035
790	21.9634	22.2405	21.9459	21.0080	21.7152	22.2136
795	22.0637	22.3190	22.0273	21.1155	21.8101	22.3190
800	22.1303	22.4177	22.0837	21.2300	21.9279	22.4467
805	22.2755	22.5687	22.2471	21.3206	21.9938	22.5114

Table 4. (cont.) Scales of spectral irradiance for FEL lamps belonging to UCSB (F303, F219, F304, and F305) and NOAA (F307 and F308) both measured in units of $\mu\text{W cm}^{-2}\text{ nm}^{-1}$; scales were transferred from lamp F269 on 22–25 June 1993. The lamp current, in amperes, is listed in each column head.

λ [nm]	F303 8.001 A	F219 8.000 A	F304 8.000 A	F305 8.000 A	F307 8.000 A	F308 8.000 A
810	22.2929	22.6004	22.2929	21.4473	22.0633	22.5996
815	22.3819	22.6841	22.3723	21.5148	22.1391	22.6829
820	22.5353	22.7913	22.4659	21.5889	22.2393	22.7504
825	22.5951	22.9028	22.5748	21.6904	22.3175	22.8319
830	22.5805	22.8996	22.6204	21.7028	22.3833	22.9001
835	22.7229	23.0029	22.6828	21.8427	22.4738	22.9624
840	22.7801	23.0498	22.7607	21.8727	22.4631	22.9791
845	22.9028	23.1306	22.7931	21.9396	22.5176	23.0706
850	22.8716	23.1870	22.8620	21.9853	22.5689	23.1174
855	22.9264	23.1994	22.8874	22.0686	22.6940	23.1992
860	22.9673	23.2270	22.9478	22.0912	22.7358	23.2643
865	23.0029	23.2686	23.0029	22.1678	22.7383	23.2680
870	23.0345	23.2589	23.0345	22.2118	22.8115	23.2961
875	23.0445	23.3578	23.0631	22.2526	22.7703	23.2920
880	23.1143	23.3316	23.0689	22.2269	22.7983	23.3033
885	23.0976	23.3565	23.1069	22.2867	22.8577	23.3909
890	23.1126	23.4024	23.1213	22.3131	22.8863	23.3760
895	23.1254	23.4023	23.1168	22.2778	22.9017	23.3758
900	23.1340	23.4077	23.1254	22.3301	22.8864	23.3461
905	23.1274	23.4315	23.1108	22.3510	22.8759	23.4141
910	23.1357	23.4120	23.1110	22.3417	22.8535	23.3782
915	23.1318	23.4058	23.1405	22.3449	22.8934	23.3387
920	23.0987	23.3944	23.0658	22.3430	22.8217	23.3444
925	23.0868	23.3724	23.0707	22.3122	22.8117	23.3231
930	23.0714	23.3651	23.1040	22.3535	22.7964	23.3075
935	23.0201	23.3471	23.0201	22.3007	22.8248	23.3465
940	23.0551	23.3073	23.0310	22.2995	22.8048	23.2907
945	22.9730	23.2993	23.0056	22.2551	22.7543	23.2416
950	22.9763	23.2713	23.0091	22.2880	22.7814	23.2383
955	22.9866	23.2093	22.9455	22.2532	22.7235	23.1750
960	22.9095	23.2425	22.9761	22.2435	22.7110	23.1751
965	22.9040	23.1734	22.9040	22.2303	22.6538	23.1061
970	22.8722	23.1365	22.8635	22.1810	22.6606	23.0944
975	22.8197	23.1239	22.8026	22.1684	22.5435	23.0275
980	22.7473	23.0834	22.7912	22.0744	22.5265	22.9848
985	22.7050	23.0123	22.7228	22.0715	22.5076	22.9314
990	22.6519	22.9675	22.7073	22.0012	22.4112	22.8927
995	22.6248	22.9412	22.6533	21.9430	22.3866	22.8450
1000	22.5673	22.8560	22.5976	21.9414	22.3503	22.8261

Table 5. Scales of spectral irradiance for FEL lamps belonging to NRIFSF (F123), UA (F296 and F297), and the DXW lamp belonging to SBRC (DXW19) measured in units of $\mu\text{W cm}^{-2}\text{nm}^{-1}$; scales were transferred from lamp F269 on 22–25 June 1993. The lamp current, in amperes, is listed in each column head.

λ [nm]	F123 7.108 A	F296 7.656 A	F297 7.656 A	DXW19 8.000 A	λ [nm]	F123 7.108 A	F296 7.656 A	F297 7.656 A	DXW19 8.000 A
350	0.7439	0.9401	0.8665	0.7065	590	12.4397	13.9739	13.4476	12.2859
355	0.8536	1.0716	0.9890	0.8019	595	12.7303	14.2888	13.7764	12.5750
360	0.9442	1.1684	1.1077	0.8942	600	13.0284	14.6274	14.0577	12.8739
365	1.0414	1.2975	1.2272	0.9902	605	13.3641	14.9368	14.3747	13.1260
370	1.1497	1.4647	1.3864	1.0979	610	13.6232	15.2221	14.6467	13.4480
375	1.2899	1.5845	1.5045	1.2162	615	13.9111	15.5115	14.9927	13.7519
380	1.4152	1.7549	1.6550	1.3336	620	14.1946	15.7987	15.2307	14.0691
385	1.5553	1.9111	1.8193	1.4788	625	14.4623	16.0852	15.5162	14.3308
390	1.7020	2.1011	1.9774	1.6109	630	14.7400	16.4077	15.7715	14.6063
395	1.8571	2.2838	2.1504	1.7685	635	15.0044	16.6675	16.0611	14.8780
400	2.0224	2.4697	2.3395	1.9230	640	15.2954	16.9435	16.3598	15.1942
405	2.2027	2.6729	2.5401	2.0947	645	15.5300	17.2156	16.5752	15.4545
410	2.3854	2.8993	2.7515	2.2669	650	15.8105	17.4638	16.8782	15.7334
415	2.5764	3.1198	2.9561	2.4494	655	16.0962	17.7546	17.1369	15.9588
420	2.7786	3.3804	3.1775	2.6479	660	16.3036	18.0084	17.4047	16.2532
425	2.9553	3.5870	3.4125	2.8183	665	16.5526	18.2418	17.6392	16.4387
430	3.2098	3.8371	3.6421	3.0591	670	16.7853	18.4791	17.8566	16.7252
435	3.4157	4.1040	3.8933	3.2758	675	17.0393	18.7388	18.1235	16.9526
440	3.6473	4.3513	4.1414	3.4944	680	17.2809	19.0009	18.3436	17.2279
445	3.8849	4.6252	4.3917	3.7201	685	17.4963	19.2314	18.6150	17.4712
450	4.1190	4.8988	4.6548	3.9542	690	17.7156	19.4259	18.7951	17.6814
455	4.3772	5.1807	4.9343	4.2047	695	17.9379	19.6152	19.0279	17.9121
460	4.6325	5.4758	5.2149	4.4558	700	18.1647	19.8668	19.2702	18.1384
465	4.8987	5.7733	5.5073	4.7198	705	18.3495	20.0482	19.4122	18.3523
470	5.1759	6.0694	5.7863	4.9844	710	18.5268	20.3011	19.6379	18.5304
475	5.4464	6.3788	6.0872	5.2553	715	18.7550	20.4577	19.8282	18.6989
480	5.7269	6.6959	6.3863	5.5379	720	18.9753	20.6572	19.9794	18.9788
485	6.0060	7.0104	6.6936	5.8141	725	19.1190	20.8133	20.1714	19.1893
490	6.2948	7.3307	6.9996	6.0986	730	19.2933	21.0095	20.3795	19.3192
495	6.5885	7.6552	7.3058	6.3846	735	19.5089	21.1691	20.5315	19.4520
500	6.8822	7.9811	7.6260	6.6803	740	19.6851	21.3155	20.6789	19.6292
505	7.1818	8.3076	7.9408	6.9751	745	19.7870	21.5242	20.8202	19.8528
510	7.4849	8.6466	8.2726	7.2788	750	19.9758	21.5970	20.9710	20.0317
515	7.7846	8.9781	8.5873	7.5845	755	20.1334	21.7537	21.1312	20.1995
520	8.0933	9.3101	8.9130	7.8888	760	20.2589	21.8846	21.2367	20.3565
525	8.3974	9.6506	9.2387	8.1997	765	20.3472	22.0332	21.3852	20.4781
530	8.7107	9.9882	9.5689	8.5099	770	20.5022	22.2051	21.5462	20.6227
535	9.0272	10.3241	9.8973	8.8194	775	20.6574	22.3044	21.6672	20.7278
540	9.3321	10.6582	10.2147	9.1359	780	20.7549	22.4674	21.7824	20.8926
545	9.6501	10.9998	10.5477	9.4553	785	20.9145	22.5218	21.8594	21.0212
550	9.9622	11.3410	10.8846	9.7690	790	20.9998	22.6408	22.0000	21.1441
555	10.2786	11.6731	11.2102	10.0809	795	21.1055	22.7552	22.1009	21.2281
560	10.5910	12.0676	11.5395	10.4022	800	21.2300	22.7977	22.2151	21.3792
565	10.8830	12.3515	11.8677	10.7194	805	21.2785	22.9169	22.3043	21.4543
570	11.2089	12.6854	12.1945	11.0275	810	21.3987	22.9826	22.3697	21.5273
575	11.5109	13.0491	12.5096	11.3470	815	21.5148	23.0713	22.4498	21.6326
580	11.8254	13.3592	12.8301	11.6544	820	21.5302	23.1236	22.5443	21.7372
585	12.1298	13.7299	13.1418	11.9726	825	21.6562	23.1881	22.5945	21.8026

Table 5. (cont.) Scales of spectral irradiance for FEL lamps belonging to NRIFSF (F123), UA (F296 and F297), and the DXW lamp belonging to SBRC (DXW19) measured in units of $\mu\text{W cm}^{-2}\text{ nm}^{-1}$; scales were transferred from lamp F269 on 22–25 June 1993. The lamp current, in amperes, is listed in each column head.

λ [nm]	F123 7.108 A	F296 7.656 A	F297 7.656 A	DXW19 8.000 A	λ [nm]	F123 7.108 A	F296 7.656 A	F297 7.656 A	DXW19 8.000 A
830	21.6933	23.2977	22.6616	21.8664	920	22.3430	23.6392	23.0663	22.5457
835	21.7918	23.3297	22.7030	22.0056	925	22.3254	23.6243	23.0548	22.5375
840	21.8772	23.3363	22.7013	21.9869	930	22.3208	23.6085	23.0394	22.5225
845	21.9207	23.3867	22.7941	22.0435	935	22.3007	23.5748	23.0204	22.5331
850	21.9905	23.4309	22.8040	22.0987	940	22.2842	23.5499	22.9992	22.5473
855	22.0186	23.5490	22.9272	22.1524	945	22.2551	23.5182	22.9571	22.5194
860	22.0570	23.5807	22.9662	22.2782	950	22.2345	23.4994	22.9772	22.4885
865	22.0919	23.6085	23.0032	22.3246	955	22.1980	23.4622	22.9283	22.4529
870	22.2118	23.6315	23.0352	22.3666	960	22.2227	23.4072	22.8767	22.4143
875	22.2289	23.6123	22.9900	22.3336	965	22.1966	23.4246	22.8710	22.4028
880	22.2182	23.6640	23.0508	22.4398	970	22.1810	23.3411	22.8647	22.3877
885	22.2867	23.6753	23.1065	22.4003	975	22.1159	23.2696	22.7509	22.4037
890	22.3131	23.7088	23.1047	22.4262	980	22.0436	23.2668	22.7028	22.3487
895	22.2696	23.7126	23.1171	22.5166	985	22.0479	23.1929	22.6519	22.2892
900	22.2877	23.7378	23.1070	22.5313	990	21.9541	23.1150	22.5964	22.2249
905	22.3013	23.6833	23.0777	22.4765	995	21.9143	23.0742	22.5394	22.2307
910	22.3417	23.7028	23.1278	22.5477	1000	21.9224	23.0431	22.4990	22.1586
915	22.3018	23.6850	23.0740	22.5485					

(Fig. 10) agrees with the SIRREX-1 (also 30 July 1992) scale within 1%, and also agrees with the NIST (October 1992) scale within 1.5% at 400 nm and less than 1% at all other wavelengths. Similar agreement is seen for F268 (Fig. 2).

For wavelengths greater than 450 nm, most 31 July 1992 SIRREX-1 scales agree with SIRREX-2 within less than 2%. These include F303 (Fig. 6), F219 (Fig. 7), F321 (Fig. 8), F12G (Fig. 11), F12H (Fig. 12), 91534 (Fig. 13), and 90572 (Fig. 15) by Hoffman Engineering, Inc. With the exception of lamp 90572, the SIRREX-2 scales for these lamps also agree with previous calibrations by lamp vendors, and/or in-house transfers by the lamp owners, within 2%. The original calibration of 90572 (Fig. 15) and the CHORS transfer to 91348 (Fig. 16), on the other hand, disagrees with the SIRREX-2 scale by as much as 5% for wavelengths greater than 450 nm with a total range of about 10%. This discrepancy varies strongly with wavelength.

The SIRREX-1 (31 July 1992) scale of F310 (Fig. 14) was approximately 2.5–3% higher in irradiance than its SIRREX-2 counterpart, for wavelengths greater than 450 nm. The SIRREX-1 (31 July 1992) scale of 91348 (Fig. 16) also disagrees with the SIRREX-2 scale by greater than 2% for wavelengths between 450 and 550 nm, and by about 2% at higher wavelengths.

At wavelengths less than 450 nm, all SIRREX-1 lamp irradiance scales show errors significantly greater than 2% relative to the corresponding SIRREX-2 scales (Figs. 6–16). In the SIRREX-2 transfers with the new grating, the

performance of the 746/ISIC is much improved in the 400–450 nm range, but the measurements between 350–400 nm show noise and instability characteristics similar to those seen at 400–450 nm in the SIRREX-1 measurements. An improved transfer radiometer setup would be required to support accurate measurements of spectral irradiance at wavelengths less than 400 nm.

3. SPHERE SOURCES

Integrating spheres are used as sources of spectral radiance by several participating laboratories. The spheres for which radiance was measured during SIRREX-2 were the:

1. GSFC sphere, illuminated by 16 internal lamps;
2. CHORS sphere, indirectly illuminated through four auxiliary spheres, initially by four 125 W lamps, but for most measurements by four new 275 W lamps, with flux levels controlled by aperture wheels in front of each lamp;
3. WFF sphere, illuminated by two external lamps, with flux levels adjusted with entrance apertures;
4. BSI sphere, illuminated with one external lamp through an adjustable entrance aperture;
5. UCSB sphere, illuminated with a calibrated FEL lamp at 50 cm through an entrance port, which may be varied from 2.54–12.7 cm in diameter; and the
6. NOAA Optronics 420M sphere irradiance source, illuminated externally, with the lamp distance

and aperture controls on the input flux level (the exit port of this sphere has a glass window).

In any case, the purpose of using an integrating sphere is to create a diffuse source of spatially and angularly uniform radiance in an exit port of diameter large enough to fill the field-of-view of a radiometer to be calibrated.

3.1 Methods

Transfer of the NIST scale of spectral irradiance from a lamp to a scale of spectral radiance for a sphere is accomplished by one of three methods.

In the method used at GSFC, the known irradiance from an FEL lamp standard of spectral irradiance is first measured by the 746/ISIC, in a setup identical to that described in Section 2.1 for lamp transfer. The responsivity of the 746/ISIC to spectral irradiance is thus determined. The entrance port of the 746/ISIC is then positioned at a known distance from the exit port of the uncalibrated integrating sphere, which is illuminated by stable lamp sources.

The apertures of the two spheres must be parallel and aligned on the mutual perpendicular joining their two centers. From the distance between the ports of the two spheres and their respective areas, it is possible to calculate, from the measured irradiance, the radiance in the exit port of the integrating sphere radiance source (Walker et al. 1987), and to thus transfer the scale of spectral irradiance from the lamp to a scale of spectral radiance for the sphere. For more information on this procedure, including a description of the measurement equation, see Appendix B in Mueller (1993), or Walker et al. (1987).

A second approach, which was also used during the SIRREX, is to first determine the spectral radiance scale of one reference sphere source using the first method discussed above (in this case the GSFC integrating sphere), and to then use that source to calibrate a narrow field-of-view transfer spectroradiometer. During SIRREX-2, the radiance scale of the GSFC sphere was transferred to several other spheres using the PR714.

In a third approach, which is used at several laboratories, the spectral irradiance from a calibrated lamp is directed at normal incidence onto a plaque for which the Bidirectional Reflectance Distribution Function (BRDF) is accurately known for at least one angle. The spectral radiance reflected from the plaque is thus calculated as the product of the BRDF and the known incident spectral irradiance from the lamp. The spectral responsivity of a radiance sensor is then calibrated by viewing the spectral radiance reflected from the plaque at the angle for which the BRDF is known. This technique may be used either to calibrate an instrument directly by viewing the plaque, or by using a transfer radiometer to determine the spectral radiance scale of an integrating sphere source. Plaque measurements of this type were carried out on 25 June 1993.

The wavelength calibrations of the 746/ISIC and PR714 monochromators were tested by measuring the UCSB sphere while it was illuminated with a mercury lamp with its spectral lines at 404.7, 435.8, 546.1, 577.0, and 579.0 nm.

3.2 Results

During SIRREX-2, an extensive series of spectral radiance measurements were made on each of the spheres listed above (Sections 1 and 3). The following radiometers were used for measurements on some, or all, of the spheres.

- a. The 746/ISIC was calibrated for each set of measurements with FEL lamp F269.
- b. The PR714 was calibrated on 19 June 1993 using the GSFC sphere radiance scale (transferred with the 746/ISIC from lamp F269) and with wavelengths adjusted on the basis of observed displacement in mercury lines.
- c. The BSIXR, a 6-channel filter transfer radiometer, was built and independently calibrated by BSI.
- d. The 6-channel SXR, was manufactured and characterized independently by NIST under contract for the SeaWiFS Project. The SXR measurements were analyzed using an effective wavelength approach. A separate report will be issued to describe this new instrument.
- e. A quantum efficient device (QED), 8-channel filter transfer radiometer, the UAXR, was built and independently characterized by S. Biggar of UA. Biggar is analyzing the UAXR data, the results of which are not included in this report.
- f. Three copies of a 7-channel OCR100 filter radiometer, manufactured by Satlantic, were used. OCR100 data, and the subsequent results (included in this document) were analyzed by S. McLean of Satlantic.

The wavelength calibration of the 746/ISIC was verified to be within 1 nm by inspecting the resolution of the mercury lines viewed via the UCSB sphere on 21 June 1993 (D. Menzies, pers. comm.); the data from this test were not recorded. PR714 measurements of the UCSB sphere, when illuminated with the mercury lamp (file 36KSSP02.VR1, recorded at 1702 on 21 June 1993) showed displacements of -1.7, -1.8, and -1.6 nm at 404.7, 435.8, and 546.1 nm, respectively, indicating that the PR714 registered wavelengths that were approximately 2 nm low. Based on these displacement estimates, 2 nm have been added to the wavelengths of all PR714 data.

The spectral radiance responsivity of the PR714 was calibrated to match the radiance scale of the GSFC sphere, as transferred from lamp F269 on 19 June 1993. The 746/ISIC was calibrated using lamp F269, and it was then

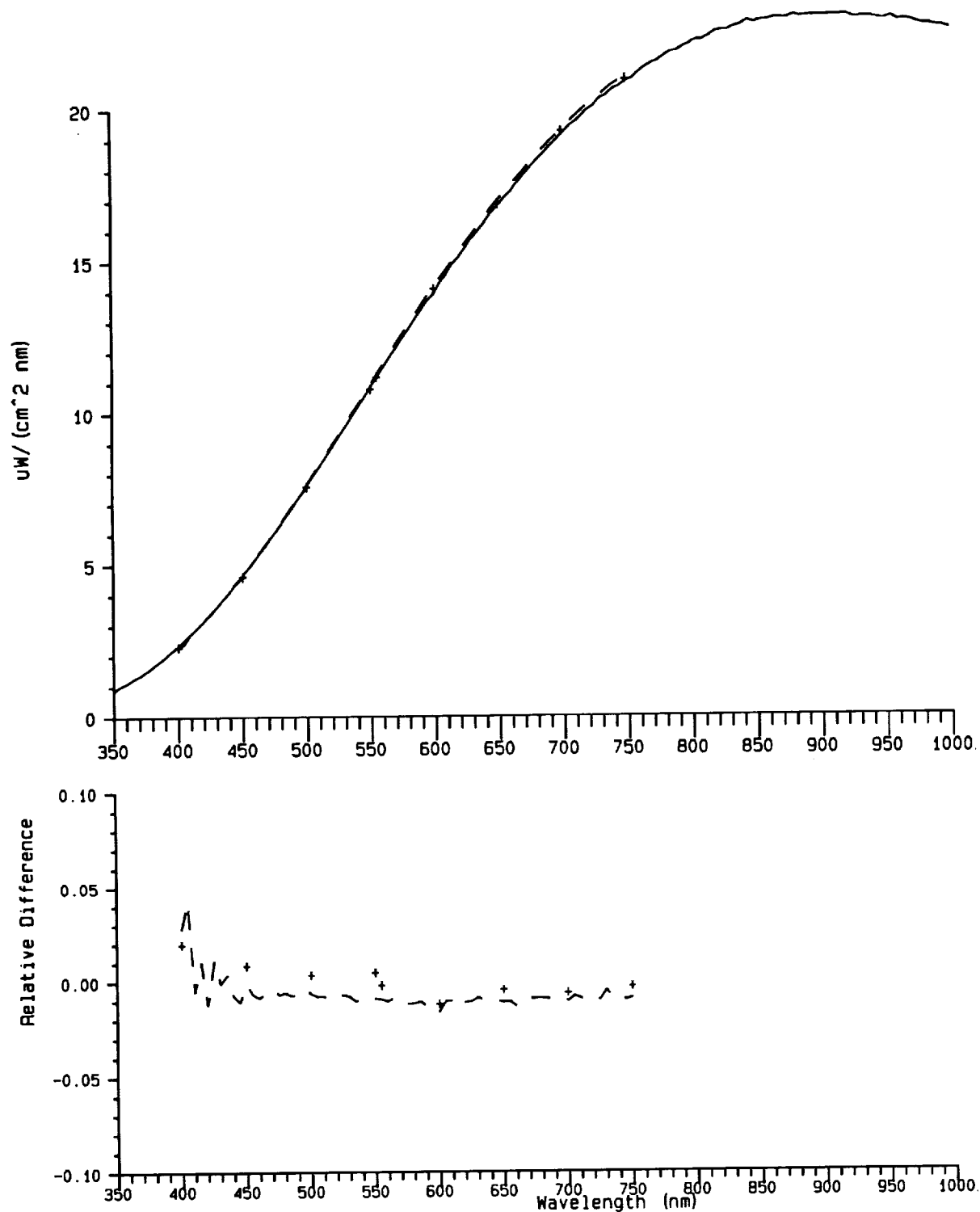


Fig. 6. Spectral irradiance of FEL lamp F303 transferred from F269 on 22 June 1993 (solid line), compared to the SIRREX-1 scale (dashed line) and the original F303 calibration by Optronics, Inc. (+). The top panel shows spectral irradiance ($\mu\text{W cm}^{-2} \text{ nm}^{-1}$) and the bottom panel illustrates discrepancies relative to the 22 June 1993 SIRREX-2 scale.

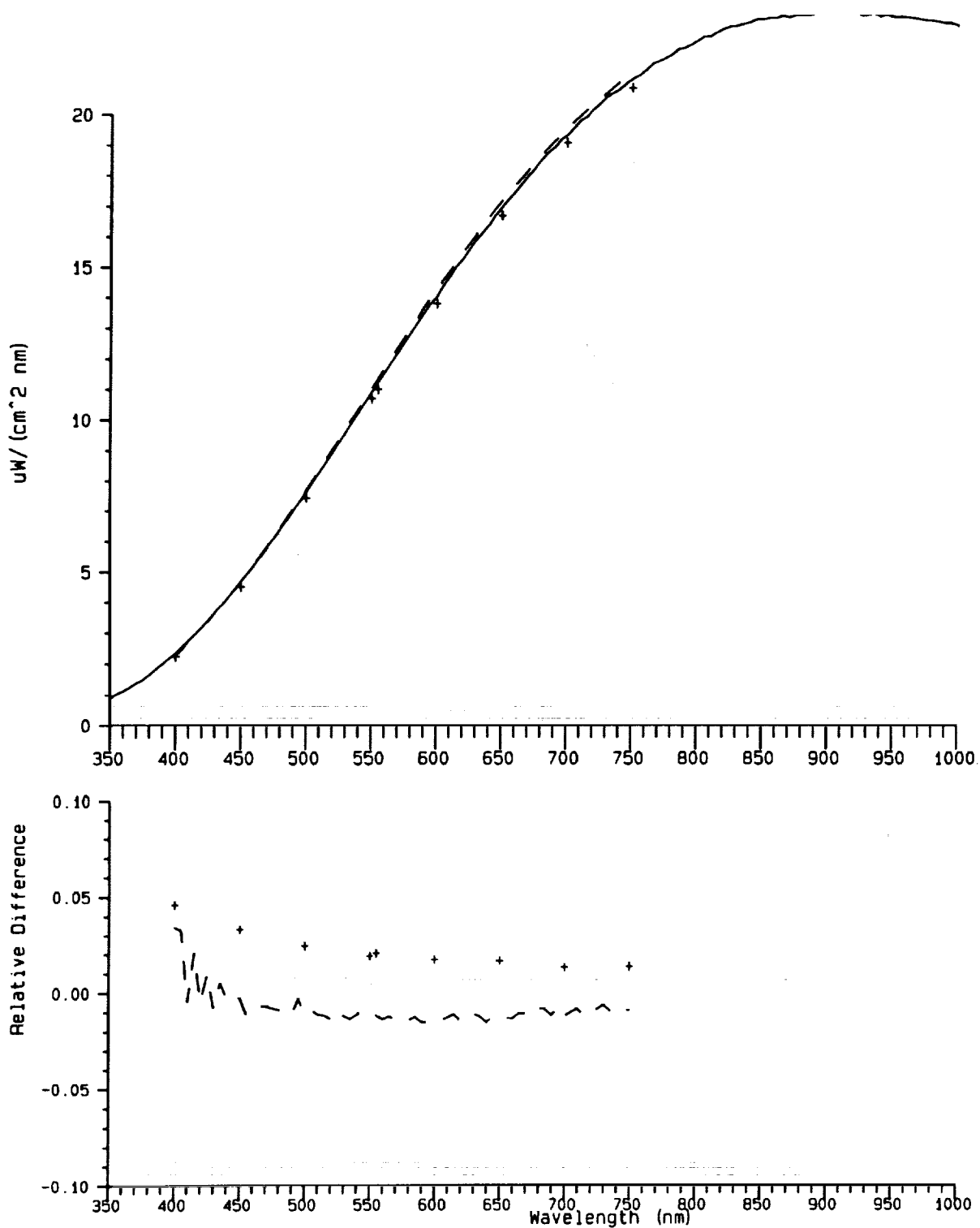


Fig. 7. Spectral irradiance of FEL lamp F219 transferred from F269 on 22 June 1993 (solid line), compared to the SIRREX-1 scale (dashed line) and the original F219 calibration by Optronics, Inc. (+). The top panel shows spectral irradiance ($\mu\text{W cm}^{-2} \text{ nm}^{-1}$) and the bottom panel illustrates discrepancies relative to the 22 June 1993 SIRREX-2 scale.

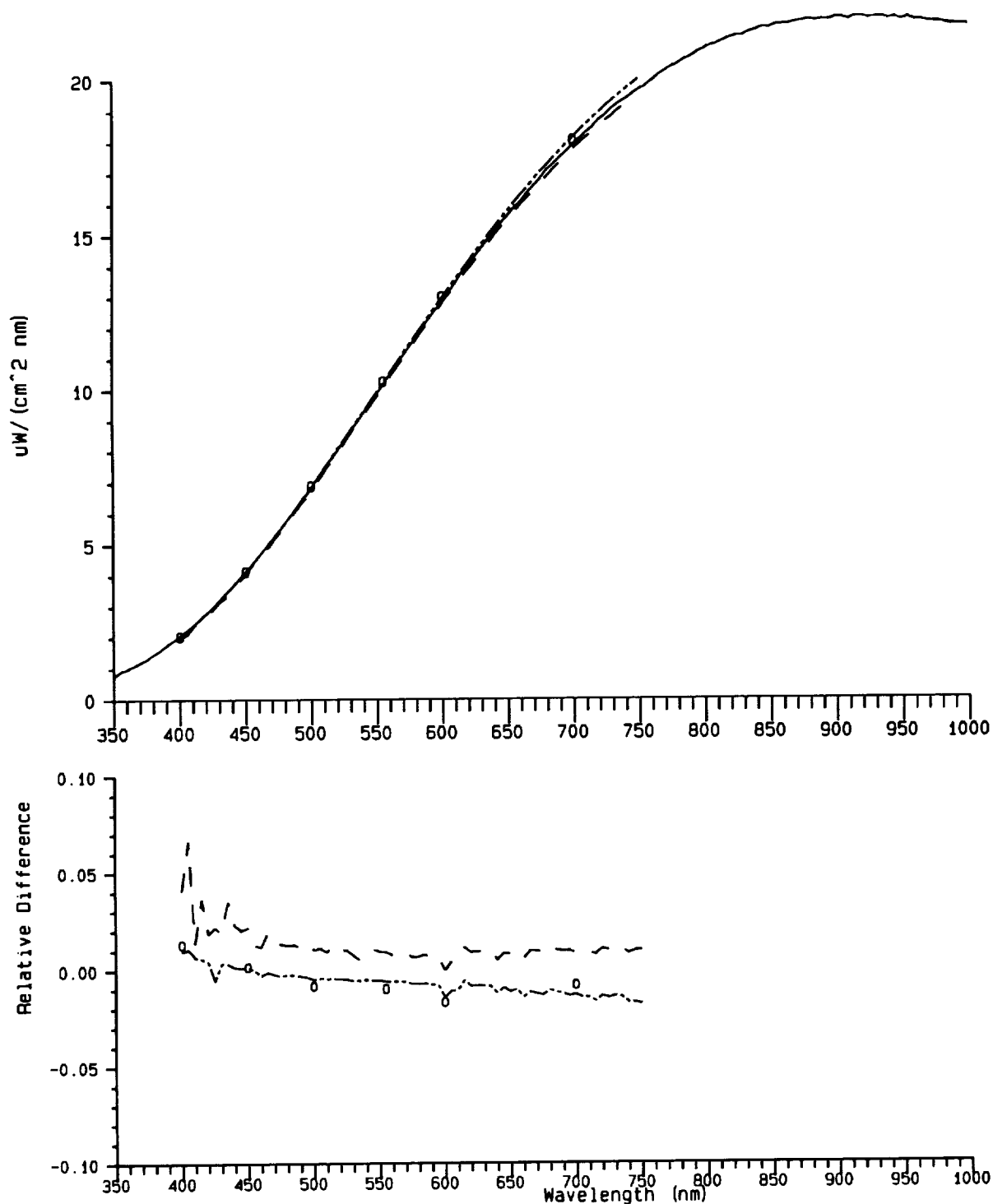


Fig. 8. Spectral irradiance of FEL lamp F321 transferred from F269 on 22 June 1993 (solid line), compared to the SIRREX-1 scale (dashed line) and the original F321 calibration by NIST in February 1991 (o) and the blackbody interpolation of the NIST calibration (— — — line). The top panel shows spectral irradiance ($\mu\text{W cm}^{-2} \text{ nm}^{-1}$) and the bottom panel illustrates discrepancies relative to the 22 June 1993 SIRREX-2 scale.

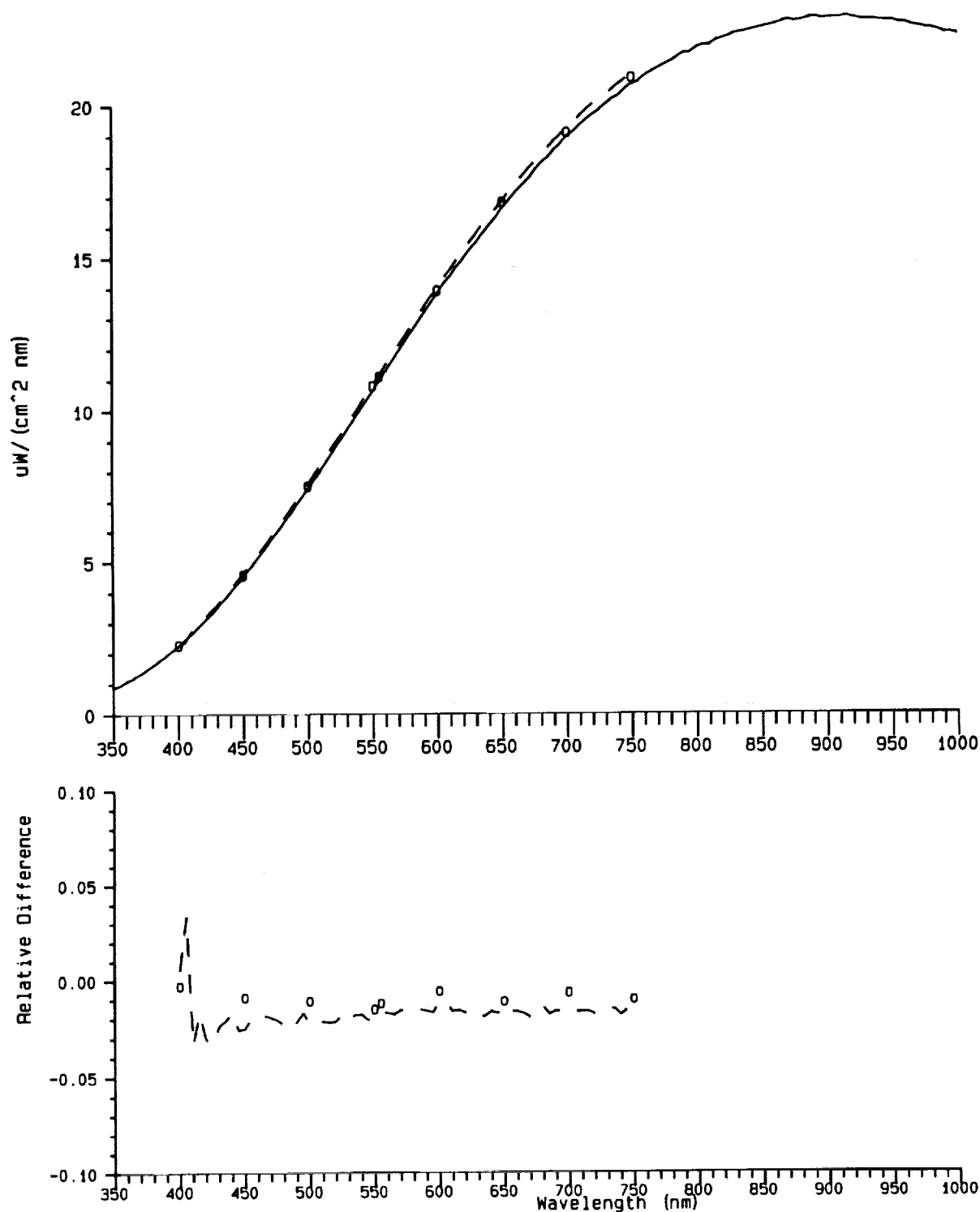


Fig. 9. Spectral irradiance of FEL lamp F307 transferred from F269 on 23 June 1993 (solid line), compared to the SIRREX-1 scale (dashed line) and the original F307 calibration by Optronics, Inc. (o). The top panel shows spectral irradiance ($\mu\text{W cm}^{-2} \text{ nm}^{-1}$) and the bottom panel illustrates discrepancies relative to the 23 June 1993 SIRREX-2 scale.

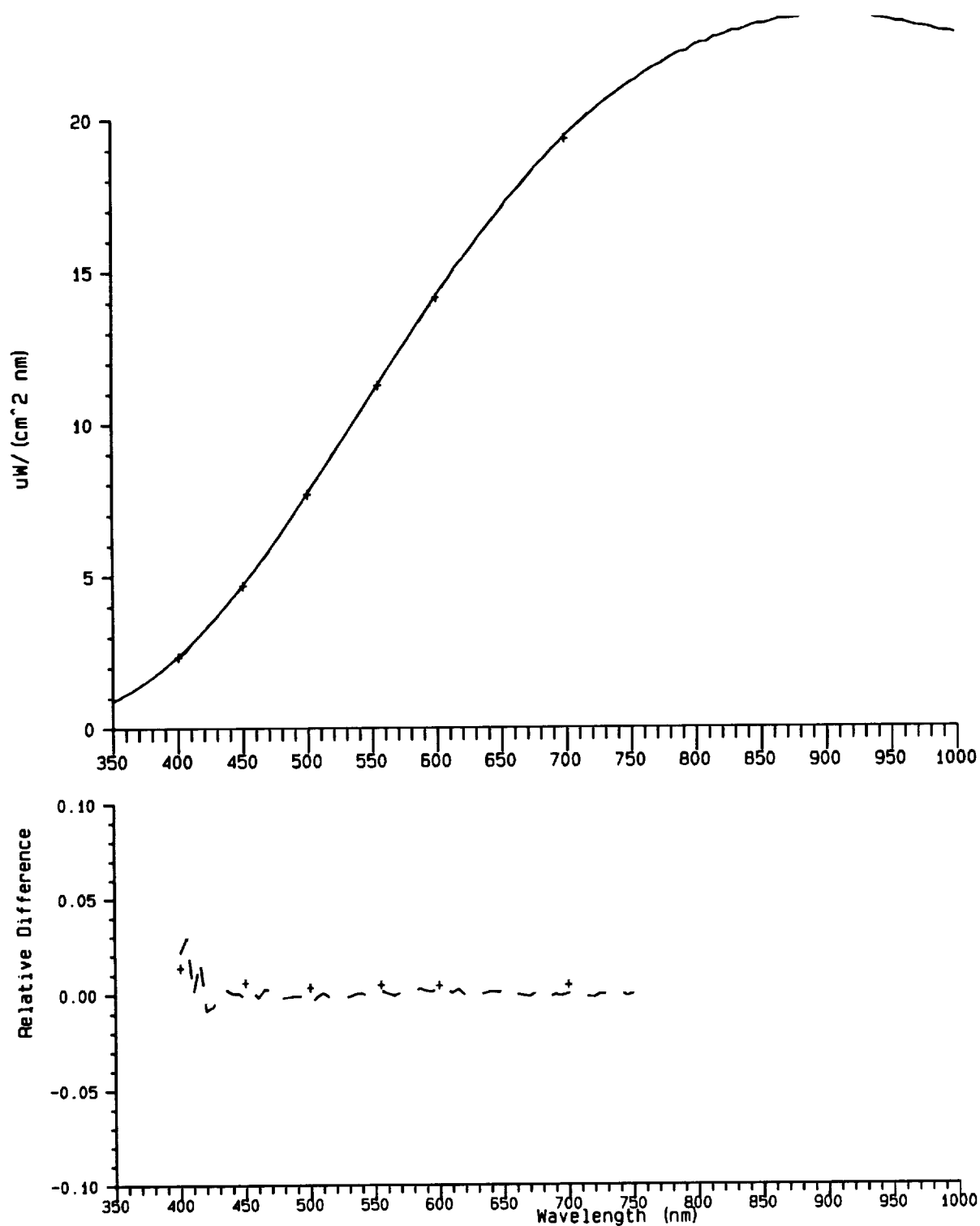


Fig. 10. Spectral irradiance of FEL lamp F308 transferred from F269 on 23 June 1993 (solid line), compared to the SIRREX-1 scale (dashed line) and the F308 calibration by NIST in October 1992 (+). The top panel shows spectral irradiance ($\mu\text{W cm}^{-2} \text{ nm}^{-1}$) and the bottom panel illustrates discrepancies relative to the 23 June 1993 SIRREX-2 scale.

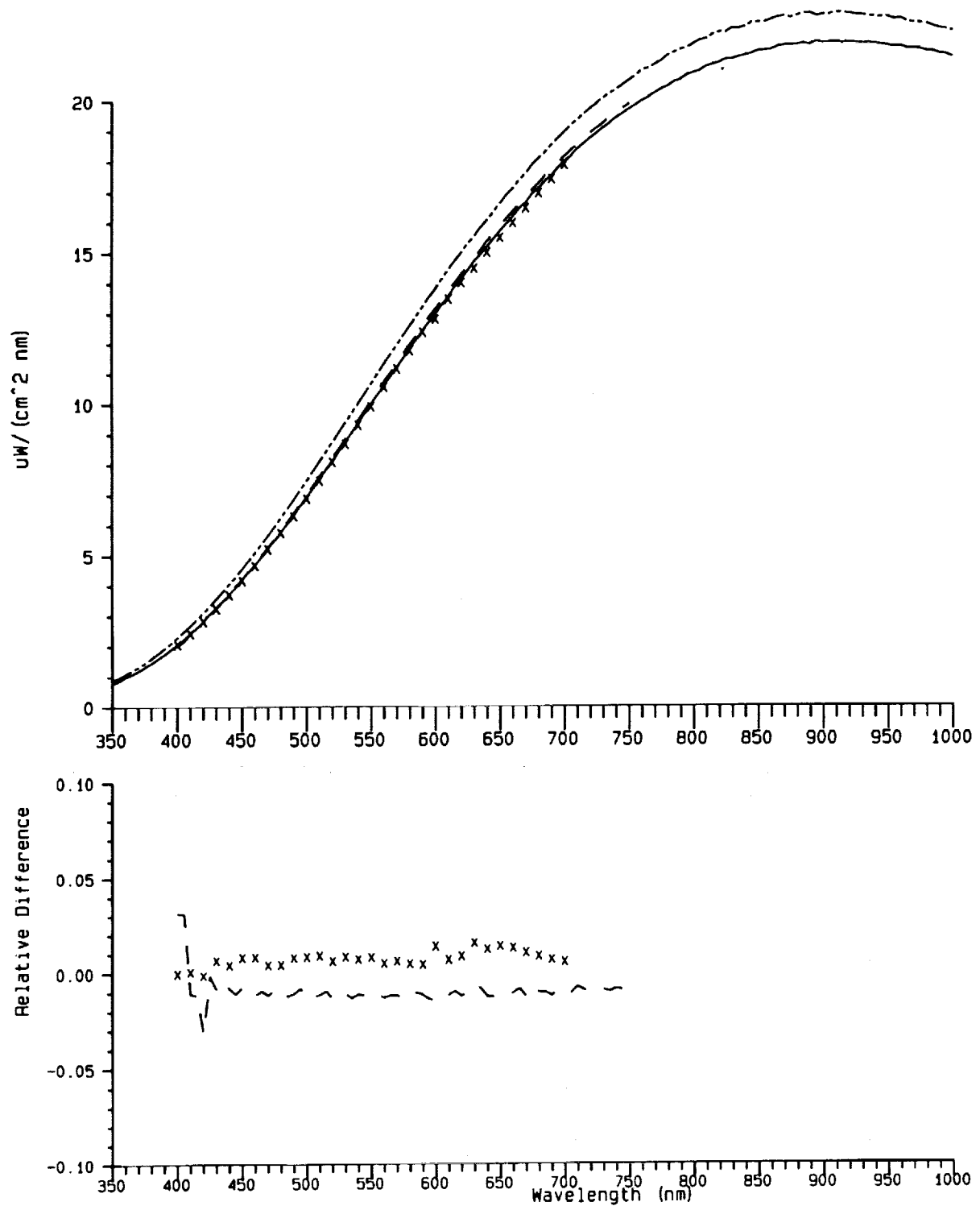


Fig. 11. Spectral irradiance of FEL lamp F12G transferred from F269 on 24 June 1993 (solid line), compared to the SIRREX-1 scale (dashed line) and the F12G calibration by UM (\times). The top panel shows spectral irradiance ($\mu\text{W cm}^{-2} \text{ nm}^{-1}$) and the bottom panel illustrates discrepancies relative to the 24 June 1993 SIRREX-2 scale. Also illustrated in the top panel, is the spectral irradiance of F12G operated at 8.000 Å (taken in error, on 23 June), rather than the 7.907 Å specified for this lamp.

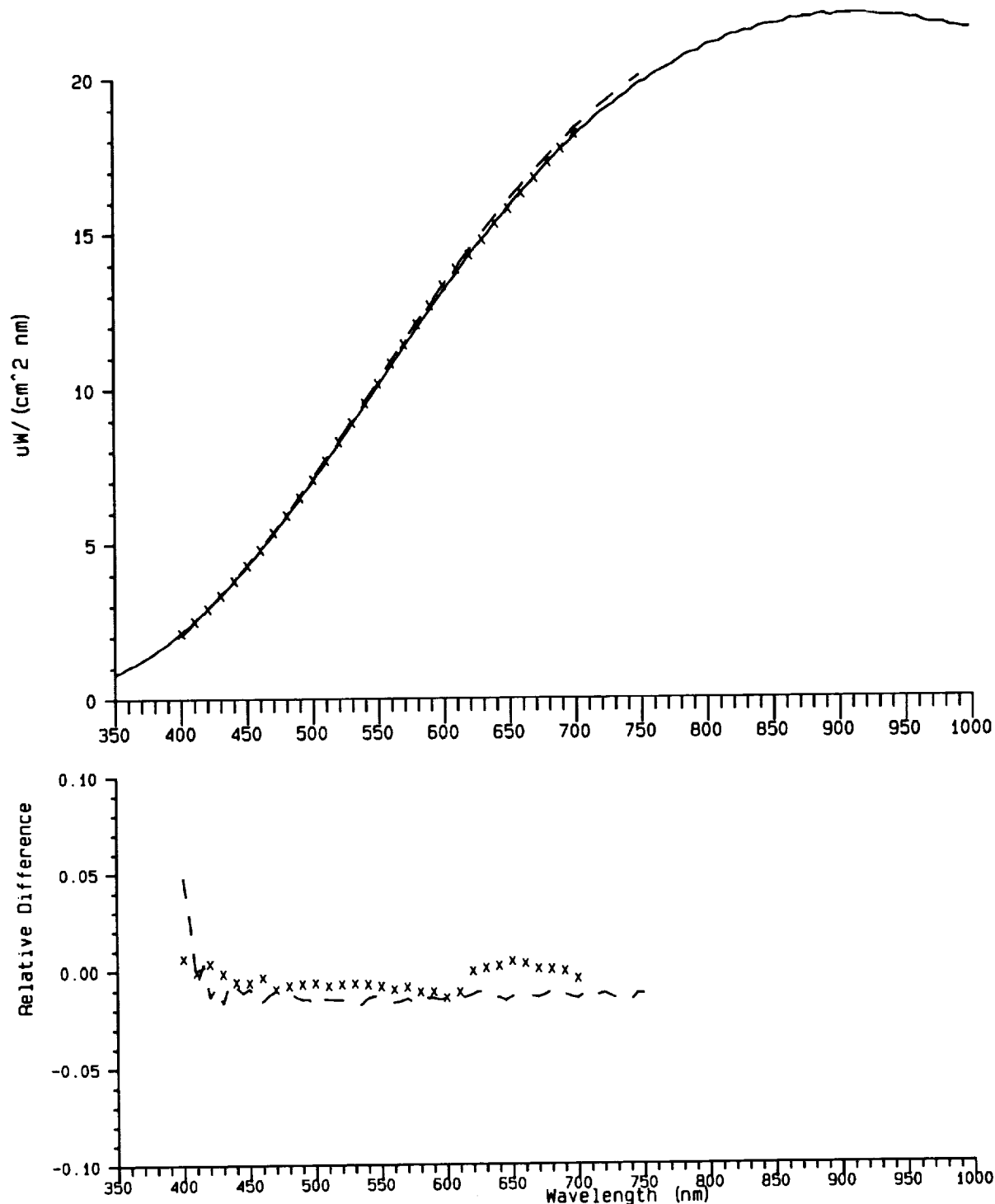


Fig. 12. Spectral irradiance of FEL lamp F12H transferred from F269 on 23 June 1993 (solid line), compared to the SIRREX-1 scale (dashed line) and the F12H calibration by UM (\times). The top panel shows spectral irradiance ($\mu\text{W cm}^{-2} \text{ nm}^{-1}$) and the bottom panel illustrates discrepancies relative to the 23 June 1993 SIRREX-2 scale.

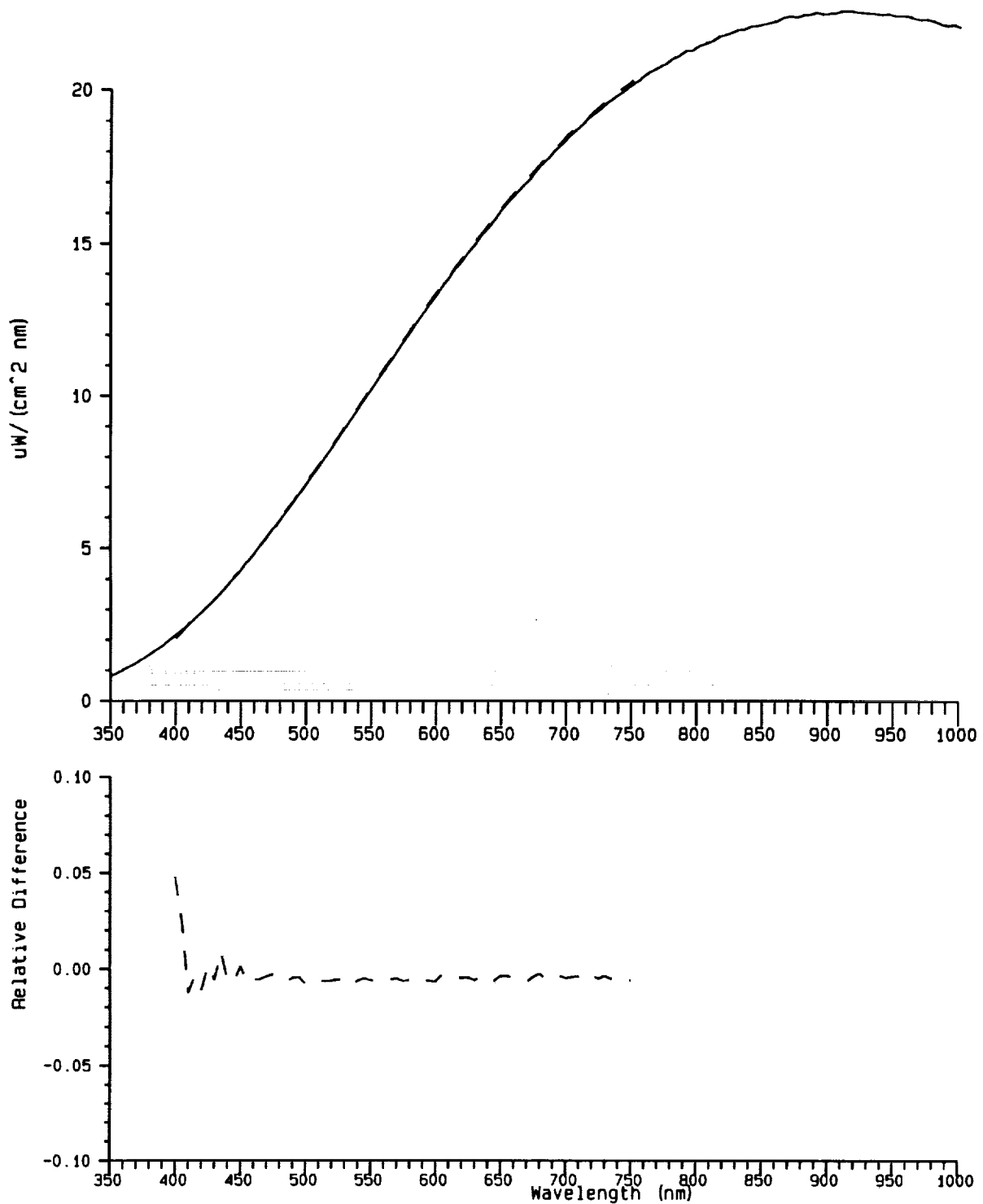


Fig. 13. Spectral irradiance of FEL lamp 91534 transferred from F269 on 23 June 1993 (solid line), compared to the SIRREX-1 scale (dashed line). The top panel shows spectral irradiance ($\mu W cm^{-2} nm^{-1}$) and the bottom panel illustrates discrepancies relative to the 23 June 1993 SIRREX-2 scale.

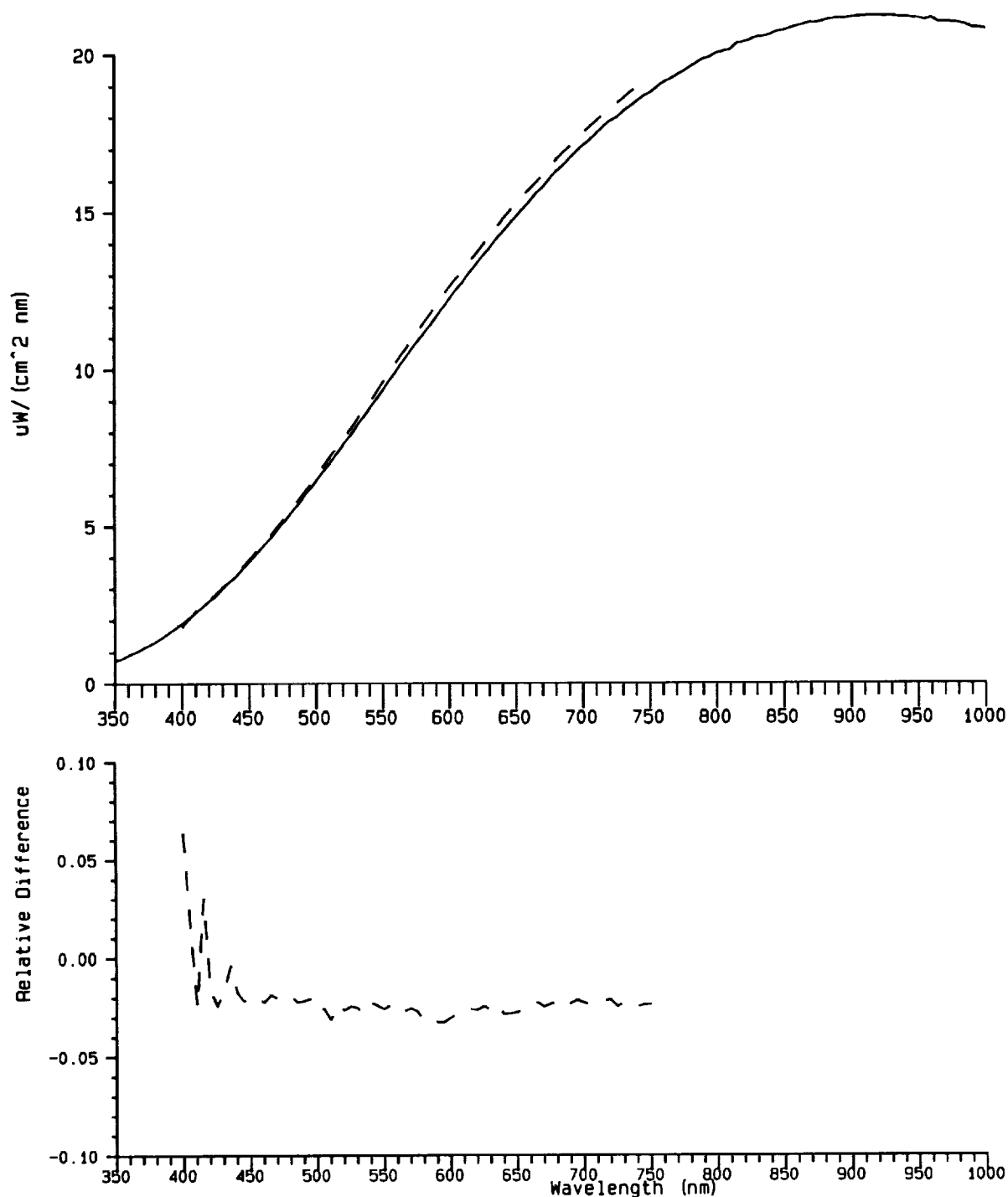


Fig. 14. Spectral irradiance of FEL lamp F310 transferred from F269 on 23 June 1993 (solid line), compared to the SIRREX-1 scale (dashed line). The top panel shows spectral irradiance ($\mu\text{W cm}^{-2} \text{ nm}^{-1}$) and the bottom panel illustrates discrepancies relative to the 23 June 1993 SIRREX-2 scale.

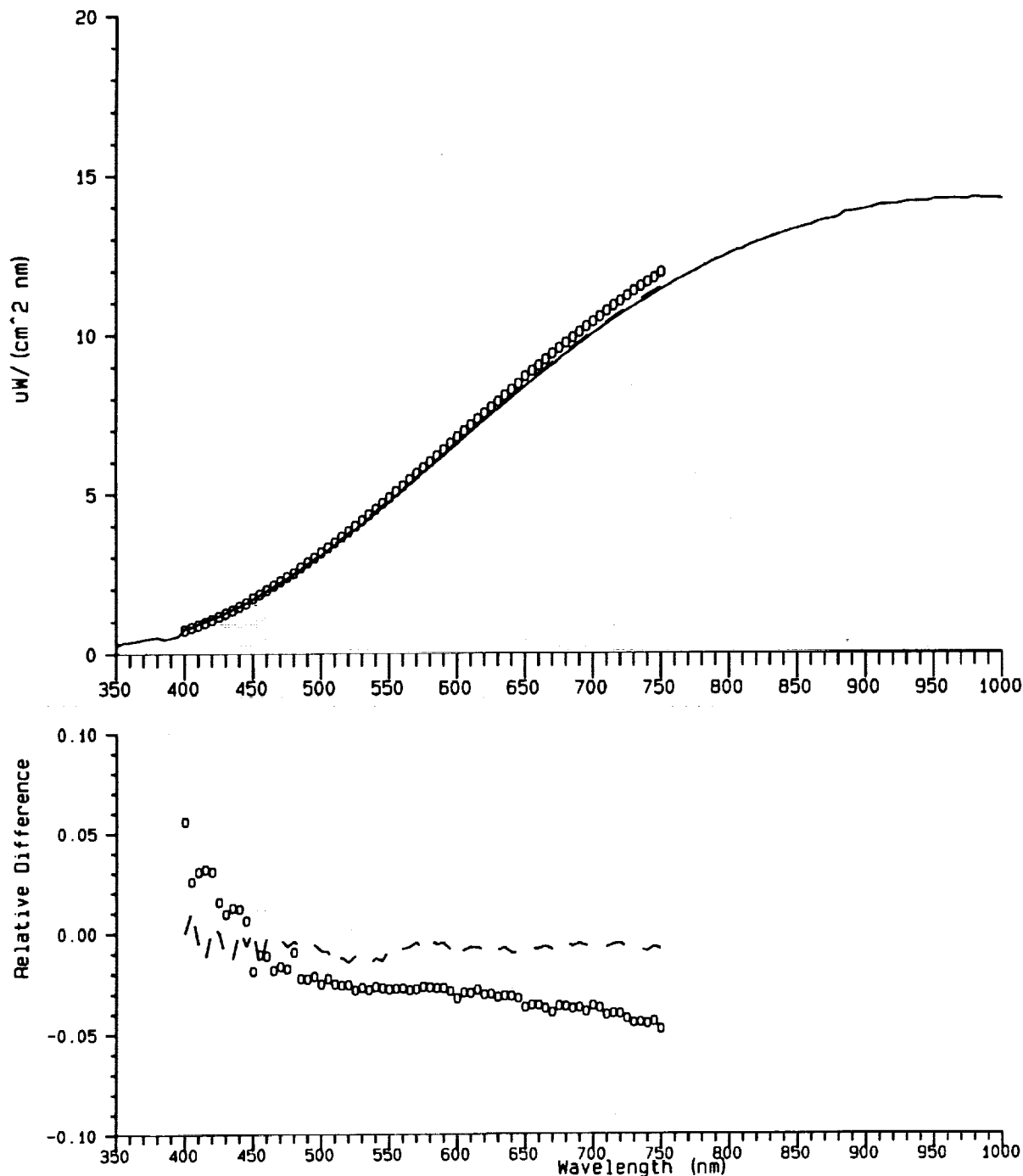


Fig. 15. Spectral irradiance of FEL lamp 90572 transferred from F269 on 23 June 1993 (solid line), compared to the SIRREX-1 scale (dashed line) and the original 90572 calibration by Hoffman Engineering, Inc. (o). The top panel shows spectral irradiance ($\mu\text{W cm}^{-2} \text{ nm}^{-1}$) and the bottom panel illustrates discrepancies relative to the 23 June 1993 SIRREX-2 scale.

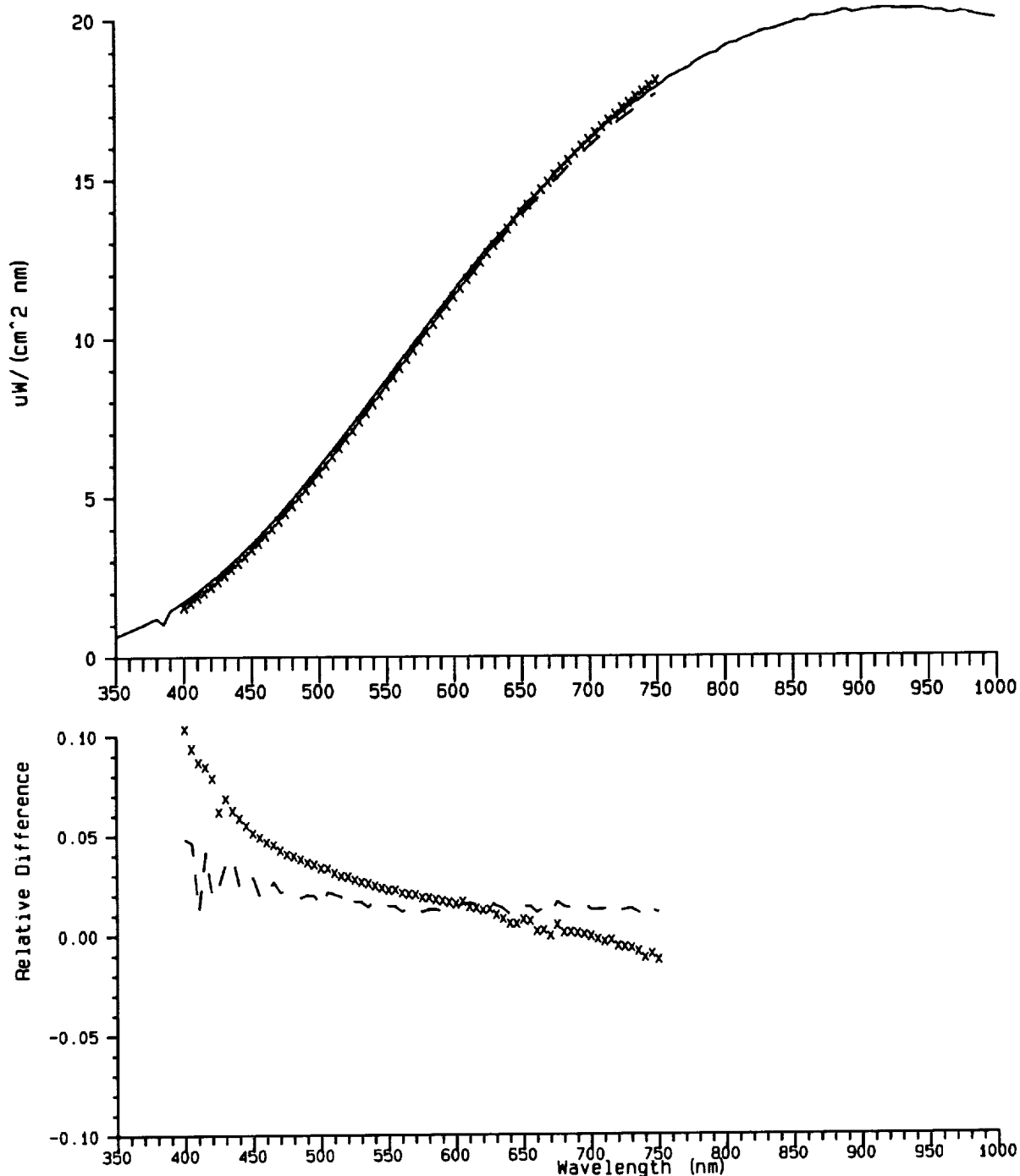


Fig. 16. Spectral irradiance of FEL lamp 91348 transferred from F269 on 23 June 1993 (solid line), compared to the SIRREX-1 scale (dashed line) and the original 91348 calibration by CHORS using 90572 (Hoffman, Fig. 15) (\times). The top panel shows spectral irradiance ($\mu\text{W cm}^{-2} \text{ nm}^{-1}$) and the bottom panel illustrates discrepancies relative to the 23 June 1993 SIRREX-2 scale.

used to measure the spectral radiance of the sphere (Section 3.1). Three separate measurements were then made of the sphere's spectral radiance with the PR714 (all using its small aperture setting). The 746/ISIC (F269) sphere radiances, measured from 350–1,000 nm in increments of 10 nm, were determined on the 4 nm interval scale of the PR714 for the range from 382–1,070 nm (after the +2 nm correction described above). Below 1,000 nm, this adjustment was made by cubic least-squares interpolation of the 746/ISIC values; beyond 1,000 nm, extrapolation was used.

Listed in Table 6 are the interpolated 746/ISIC measurements of the GSFC sphere; the results of the three PR714 measurements (on separate columns); and calibration factors by which the PR714 radiances, which were acquired using the small aperture, must be multiplied to match the GSFC sphere scale. These calibration factors, $\bar{F}(\lambda)$, are the average of the three calibration factors $F(\lambda)$ that correspond to each PR714 measurement. The standard deviations, σ , reported in Table 6, which are no larger than 0.1% for wavelengths beyond 400 nm, can be taken to represent one component of uncertainty in the transfer.

In the course of the series of PR714 measurements of the CHORS sphere on 18–19 June 1993, the instrument's aperture setting was switched (between spectral scans) from small to large, yielding four comparisons between the PR714 responses at the two settings, where each pair of measurements was made with a fixed target radiance and measurement geometry. The ratios of these responses are listed in Table 7, together with the average. These PR714 responsivity ratios decrease rapidly from 10% at 382 nm, then to near 5%, and then more gradually to stabilize between 3% and 4% at wavelengths greater than 500 nm. To calibrate PR714 radiance data to match the scale of the GSFC sphere when the instrument is set with its large aperture, it is necessary to divide by the ratios of Table 7, after first multiplying the raw data by the corresponding calibration factors in Table 6 (derived from PR714 small aperture data). This additional correction was applied to all large aperture PR714 data presented here.

The differences noted above (3–10%) between small and large aperture readings of the CHORS sphere with the PR714, are far greater than the differences at either aperture setting when the sphere was viewed first normal to the exit port and then from 10% off axis (less than 1% at all wavelengths) on 18 June 1993 (Table 7). This degree of agreement between two different viewing geometries, in each case, supports the assumption that the observed differences between small and large aperture readings were not an artifact of radiance inhomogeneity in the sphere, but are rather a characteristic of the PR714 itself.

As a general comment, the *Relative Difference* curves presented in Figs. 17–20 and 22–26 (lower panels) follow the same non-intuitive convention as the counterpart relative irradiance differences in Figs. 1–16, as explained at the end of Section 2.2 above.

3.2.1 The GSFC Sphere

Spectral radiance of the GSFC sphere was measured with the 746/ISIC on 15, 16, and 19 June 1993, shortly after the radiometer's calibration with lamp F269 (Tables 6 and 8). The calibrated sphere radiance scales (746/ISIC) from these three days are compared with each other and with the radiance scale of the sphere during SIRREX-1 (in July 1992), in Fig. 17. During SIRREX-2 in June 1993, the radiance scale of the GSFC sphere had decreased by approximately 3% at all wavelengths since July 1992. From day to day during the first week of SIRREX-2, the sphere radiance scale, as measured and calibrated with the 746/ISIC and lamp F269, appeared to be stable within approximately 1% (Fig. 17, lower panel). However, these relative differences, which are referenced to the SIRREX-1 results, are wavelength dependent with about a 1% variability.

In addition to the calibration measurements on 19 June 1993 (Table 8), the radiance of the GSFC sphere was measured with the PR714 on 21–23 June 1993 (Tables 9 and 10). The first PR714 scan on 21 June was recorded before the sphere had fully warmed up, and overall radiance was about 3% low at all wavelengths, relative to the GSFC scale of 19 June (746/ISIC and F269) and to the subsequent measurements on that day; the measurements made following adequate sphere warm-up agreed with the 19 June (746/ISIC and F269) scale within approximately 1%, and agreement between these three (at approximately 1 hour intervals) was even better (Fig. 19, lower panel).

PR714 measurements of the GSFC sphere on 22 June are shown in Fig. 20; these readings were made in rapid sequence over a total span of one hour, with the first six clustered in the three minutes between 0918 and 0921 PDT. The goal was to study the effect of varying the lens focus distance setting of the PR714. Internal agreement was generally within less than 1%, except for 1) the scan at 0921 PDT, which disagreed with the other five by approximately 1.5%, and 2) with the reading at 1013 PDT (Fig. 20, lower panel). All of these PR714 radiance spectra exceeded the 19 June scale of the sphere, by approximately 1% at 400 nm, and the difference monotonically increased to 3% at 1000 nm, with the 0921 outlier scan being in slightly better agreement. These scans on 22 June were made with the radiometer's object distance fixed at 86.4 cm, and the lens focus distance setting was varied from 0.3 m to infinity (∞). Scans at 0918 and 1013 were made in the usual way, i.e., the PR714 was focused on the exit aperture of the sphere. The outlier scan at 0921 (above) was taken with a 0.3 m focus distance.

On 19 June 1993, SXR radiance measurements (corrected for out-of-field sensitivity) of the GSFC sphere, agree with the 746/ISIC and the calibrated PR714 data within less than 2% at all wavelengths, and within less than 0.5% for $450 < \lambda < 700$ nm (Table 8). On subsequent days, the SXR data depart from the PR714 measurements by 2–5%

Table 6. Comparison of NIST PR714 radiance measurements on the GSFC sphere and $\bar{F}(\lambda)$ to convert the PR714 readings to match the spectral radiance scale of the GSFC sphere (as calibrated with the 746/ISIC using the spectral irradiance scale of FEL lamp F269). At each wavelength (λ), corrected radiance $L(\lambda)$ is calculated as $L(\lambda) = \bar{F}(\lambda)L_{714}(\lambda)$, where, $L_{714}(\lambda)$ is the PR714 raw radiance ($P_i, i = 1, 3$) (multiplied by 100 to convert to units of $\mu\text{W cm}^{-2} \text{nm}^{-1} \text{sr}^{-1}$). This adjustment completes the correction for small aperture PR714 measurements. For large aperture PR714 measurements, however, $L(\lambda)$ must also be divided by the corresponding Average Ratio from Table 7. These results are based on the 746/ISIC file P930619B.DAT (19 June 1993, 1620 PDT) and the three PR714 data files: (P_i), subscript 1 refers to 36IGSP00.VR1 (19 June 1993, 1705 PDT), subscript 2 refers to 36IGSP00.VR2 (19 June 1993, 1715 PDT), and subscript 3 refers to 36IGSP00.VR3 (19 June 1993, 1725 PDT). The $\bar{F}(\lambda)$ and σ values are computed from these same data files. The symbol δ_i is the relative difference and is defined as $F_i - \bar{F}(\lambda)$.

λ [nm]	GSFC (L)	$\bar{F}(\lambda)$	σ	P_1	P_2	P_3	F_1	F_2	F_3	δ_1	δ_2	δ_3
382	1.7729	0.9882	0.0169	1.7930	1.7580	1.8330	0.9888	1.0085	0.9672	0.0006	0.0206	-0.0212
386	1.9830	1.0096	0.0065	1.9810	1.9500	1.9620	1.0010	1.0169	1.0107	-0.0085	0.0073	0.0011
390	2.2001	1.0406	0.0136	2.1370	2.0760	2.1310	1.0295	1.0598	1.0324	-0.0106	0.0185	-0.0078
394	2.4221	1.0803	0.0040	2.2530	2.2400	2.2330	1.0750	1.0813	1.0847	-0.0049	0.0009	0.0040
398	2.6471	1.0763	0.0005	2.4610	2.4590	2.4580	1.0756	1.0765	1.0769	-0.0007	0.0001	0.0005
402	2.8755	1.0632	0.0010	2.7070	2.7060	2.7010	1.0622	1.0626	1.0646	-0.0009	-0.0005	0.0014
406	3.1191	1.0534	0.0048	2.9680	2.9420	2.9730	1.0509	1.0602	1.0491	-0.0024	0.0064	-0.0041
410	3.3788	1.0588	0.0042	3.1860	3.1790	3.2090	1.0605	1.0628	1.0529	0.0017	0.0039	-0.0055
414	3.6534	1.0692	0.0021	3.4080	3.4190	3.4240	1.0720	1.0686	1.0670	0.0026	-0.0006	-0.0020
418	3.9415	1.0556	0.0025	3.7310	3.7460	3.7250	1.0564	1.0522	1.0581	0.0008	-0.0032	0.0024
422	4.2419	1.0343	0.0014	4.1090	4.0990	4.0960	1.0323	1.0349	1.0356	-0.0019	0.0006	0.0013
426	4.5533	1.0396	0.0009	4.3810	4.3840	4.3750	1.0393	1.0386	1.0407	-0.0002	-0.0009	0.0011
430	4.8743	1.0459	0.0007	4.6650	4.6580	4.6580	1.0449	1.0464	1.0464	-0.0010	0.0005	0.0005
434	5.2037	1.0487	0.0030	4.9820	4.9480	4.9570	1.0445	1.0517	1.0498	-0.0040	0.0029	0.0011
438	5.5402	1.0343	0.0015	5.3600	5.3460	5.3640	1.0336	1.0363	1.0328	-0.0006	0.0020	-0.0014
442	5.8825	1.0087	0.0013	5.8310	5.8230	5.8410	1.0088	1.0102	1.0071	0.0001	0.0015	-0.0016
446	6.2293	1.0119	0.0016	6.1470	6.1510	6.1700	1.0134	1.0127	1.0096	0.0015	0.0008	-0.0023
450	6.5792	1.0231	0.0006	6.4280	6.4360	6.4280	1.0235	1.0223	1.0235	0.0004	-0.0008	0.0004
454	6.9377	1.0296	0.0011	6.7340	6.7480	6.7320	1.0303	1.0281	1.0306	0.0006	-0.0015	0.0009
458	7.3102	1.0274	0.0009	7.1070	7.1220	7.1160	1.0286	1.0264	1.0273	0.0011	-0.0010	-0.0001
462	7.6954	1.0191	0.0013	7.5460	7.5430	7.5650	1.0198	1.0202	1.0172	0.0007	0.0011	-0.0018
466	8.0923	0.9955	0.0011	8.1180	8.1290	8.1400	0.9968	0.9955	0.9941	0.0014	0.0000	-0.0014
470	8.4995	0.9927	0.0002	8.5630	8.5590	8.5630	0.9926	0.9931	0.9926	-0.0002	0.0003	-0.0002
474	8.9160	1.0101	0.0005	8.8300	8.8300	8.8210	1.0097	1.0097	1.0108	-0.0003	-0.0003	0.0007
478	9.3406	1.0308	0.0018	9.0520	9.0500	9.0840	1.0319	1.0321	1.0283	0.0011	0.0013	-0.0024
482	9.7721	1.0378	0.0011	9.4020	9.4220	9.4240	1.0394	1.0372	1.0369	0.0015	-0.0006	-0.0009
486	10.2093	1.0303	0.0004	9.9040	9.9130	9.9100	1.0308	1.0299	1.0302	0.0005	-0.0004	-0.0001
490	10.6511	1.0067	0.0000	10.5800	10.5800	10.5800	1.0067	1.0067	1.0067	0.0000	0.0000	0.0000
494	11.0962	0.9940	0.0008	11.1700	11.1500	11.1700	0.9934	0.9952	0.9934	-0.0006	0.0012	-0.0006
498	11.5436	0.9940	0.0008	11.6200	11.6200	11.6000	0.9934	0.9934	0.9951	-0.0006	-0.0006	0.0011

Table 6. (cont.) Comparison of NIST PR714 radiance measurements on the GSFC sphere and $\bar{F}(\lambda)$ to convert the PR714 readings to match the spectral radiance scale of the GSFC sphere (as calibrated with the 746/ISIC using the spectral irradiance scale of FEL lamp F269). At each wavelength (λ), corrected radiance $L(\lambda)$ is calculated as $L(\lambda) = \bar{F}(\lambda)L_{714}(\lambda)$, where, $L_{714}(\lambda)$ is the PR714 raw radiance ($P_i, i = 1, 3$) (multiplied by 100 to convert to units of $\mu\text{W cm}^{-2}\text{nm}^{-1}\text{sr}^{-1}$). This adjustment completes the correction for small aperture PR714 measurements. For large aperture PR714 measurements, however, $L(\lambda)$ must also be divided by the corresponding Average Ratio from Table 7. These results are based on the 746/ISIC file P930619B.DAT (19 June 1993, 1620 PDT) and the three PR714 data files: (P_i), subscript 1 refers to 36IGSP00.VR1 (19 June 1993, 1705 PDT), subscript 2 refers to 36IGSP00.VR2 (19 June 1993, 1715 PDT), and subscript 3 refers to 36IGSP00.VR3 (19 June 1993, 1725 PDT). The $\bar{F}(\lambda)$ and σ values are computed from these same data files. The symbol δ_i is the relative difference and is defined as $F_i - \bar{F}(\lambda)$.

λ [nm]	GSFC (L)	$\bar{F}(\lambda)$	σ	P_1	P_2	P_3	F_1	F_2	F_3	δ_1	δ_2	δ_3
502	11.9931	1.0042	0.0004	11.9400	11.9400	11.9500	1.0044	1.0044	1.0036	0.0003	0.0003	-0.0006
506	12.4505	1.0147	0.0007	12.2600	12.2700	12.2800	1.0155	1.0147	1.0139	0.0008	0.0000	-0.0008
510	12.9159	1.0167	0.0008	12.6900	12.7100	12.7100	1.0178	1.0162	1.0162	0.0011	-0.0005	-0.0005
514	13.3886	1.0148	0.0010	13.1900	13.1800	13.2100	1.0151	1.0158	1.0135	0.0003	0.0010	-0.0013
518	13.8676	1.0068	0.0007	13.7800	13.7600	13.7800	1.0064	1.0078	1.0064	-0.0005	0.0010	-0.0005
522	14.3520	0.9981	0.0006	14.3900	14.3800	14.3700	0.9974	0.9981	0.9988	-0.0007	0.0000	0.0007
526	14.8410	0.9925	0.0006	14.9600	14.9600	14.9400	0.9920	0.9920	0.9934	-0.0004	-0.0004	0.0009
530	15.3335	0.9998	0.0003	15.3300	15.3400	15.3400	1.0002	0.9996	0.9996	0.0004	-0.0002	-0.0002
534	15.8288	1.0132	0.0003	15.6200	15.6300	15.6200	1.0134	1.0127	1.0134	0.0002	-0.0004	0.0002
538	16.3259	1.0214	0.0008	16.0000	15.9800	15.9700	1.0204	1.0216	1.0223	-0.0010	0.0002	0.0008
542	16.8239	1.0227	0.0005	16.4400	16.4500	16.4600	1.0234	1.0227	1.0221	0.0006	0.0000	-0.0006
546	17.3220	1.0223	0.0003	16.9400	16.9500	16.9400	1.0226	1.0219	1.0226	0.0002	-0.0004	0.0002
550	17.8192	1.0065	0.0003	17.7000	17.7000	17.7100	1.0067	1.0067	1.0062	0.0002	0.0002	-0.0004
554	18.3176	0.9898	0.0003	18.5100	18.5100	18.5000	0.9896	0.9896	0.9901	-0.0002	-0.0002	0.0004
558	18.8190	0.9910	0.0004	18.9900	18.9800	19.0000	0.9910	0.9915	0.9905	0.0000	0.0005	-0.0005
562	19.3228	0.9964	0.0006	19.3800	19.3900	19.4100	0.9970	0.9965	0.9955	0.0007	0.0002	-0.0009
566	19.8280	1.0031	0.0005	19.7600	19.7800	19.7600	1.0034	1.0024	1.0034	0.0003	-0.0007	0.0003
570	20.3337	1.0148	0.0002	20.0300	20.0400	20.0400	1.0152	1.0147	1.0147	0.0003	-0.0002	-0.0002
574	20.8391	1.0189	0.0002	20.4600	20.4500	20.4500	1.0185	1.0190	1.0190	-0.0003	0.0002	0.0002
578	21.3433	1.0215	0.0002	20.8900	20.9000	20.8900	1.0217	1.0212	1.0217	0.0002	-0.0003	0.0002
582	21.8455	1.0167	0.0002	21.4800	21.4900	21.4900	1.0170	1.0165	1.0165	0.0003	-0.0002	-0.0002
586	22.3449	1.0053	0.0002	22.2300	22.2200	22.2300	1.0052	1.0056	1.0052	-0.0001	0.0003	-0.0001
590	22.8404	0.9931	0.0000	23.0000	23.0000	23.0000	0.9931	0.9931	0.9931	0.0000	0.0000	0.0000
594	23.3313	0.9864	0.0008	23.6400	23.6800	23.6400	0.9869	0.9853	0.9869	0.0006	-0.0011	0.0006
598	23.8168	0.9858	0.0009	24.1500	24.1900	24.1400	0.9862	0.9846	0.9866	0.0004	-0.0012	0.0008
602	24.2969	0.9927	0.0007	24.4700	24.5000	24.4600	0.9929	0.9917	0.9933	0.0003	-0.0010	0.0007
606	24.7767	0.9993	0.0002	24.7900	24.8000	24.7900	0.9995	0.9991	0.9995	0.0001	-0.0003	0.0001
610	25.2566	1.0065	0.0005	25.0800	25.1100	25.0900	1.0070	1.0058	1.0066	0.0005	-0.0007	0.0001
614	25.7357	1.0160	0.0003	25.3200	25.3400	25.3300	1.0164	1.0156	1.0160	0.0004	-0.0004	0.0000
618	26.2132	1.0206	0.0002	25.6800	25.6900	25.6800	1.0208	1.0204	1.0208	0.0001	-0.0003	0.0001

Table 6. (cont.) Comparison of NIST PR714 radiance measurements on the GSFC sphere and $\bar{F}(\lambda)$ to convert the PR714 readings to match the spectral radiance scale of the GSFC sphere (as calibrated with the 746/ISIC using the spectral irradiance scale of FEL lamp F269). At each wavelength (λ), corrected radiance $L(\lambda)$ is calculated as $L(\lambda) = \bar{F}(\lambda)L_{714}(\lambda)$, where, $L_{714}(\lambda)$ is the PR714 raw radiance ($P_i, i = 1, 3$) (multiplied by 100 to convert to units of $\mu\text{W cm}^{-2}\text{sr}^{-1}$). This adjustment completes the correction for small aperture PR714 measurements. For large aperture PR714 measurements, however, $L(\lambda)$ must also be divided by the corresponding Average Ratio from Table 7. These results are based on the 746/ISIC file P930619B.DAT (19 June 1993, 1620 PDT) and the three PR714 data files: (P_1), subscript 1 refers to 36IGSP00.VR1 (19 June 1993, 1705 PDT), subscript 2 refers to 36IGSP00.VR2 (19 June 1993, 1715 PDT), and subscript 3 refers to 36IGSP00.VR3 (19 June 1993, 1725 PDT). The $\bar{F}(\lambda)$ and σ values are computed from these same data files. The symbol δ_i is the relative difference and is defined as $F_i - \bar{F}(\lambda)$.

λ [nm]	GSFC (L)	$\bar{F}(\lambda)$	σ	P_1	P_2	P_3	F_1	F_2	F_3	δ_1	δ_2	δ_3
622	26.6883	1.0184	0.0004	26.2000	26.2000	26.2200	1.0186	1.0186	1.0179	0.0003	0.0003	-0.0005
626	27.1602	1.0141	0.0004	26.7900	26.7900	26.7700	1.0138	1.0138	1.0146	-0.0002	-0.0002	0.0005
630	27.6282	1.0091	0.0003	27.3900	27.3700	27.3800	1.0087	1.0094	1.0091	-0.0004	0.0004	0.0000
634	28.0914	1.0010	0.0004	28.0600	28.0800	28.0500	1.0011	1.0004	1.0015	0.0001	-0.0006	0.0005
638	28.5491	0.9953	0.0002	28.6900	28.6800	28.6800	0.9951	0.9954	0.9954	-0.0002	0.0001	0.0001
642	29.0004	0.9946	0.0009	29.1700	29.1200	29.1800	0.9942	0.9959	0.9938	-0.0005	0.0013	-0.0008
646	29.4446	0.9987	0.0004	29.4800	29.4700	29.5000	0.9988	0.9991	0.9981	0.0001	0.0005	-0.0006
650	29.8809	0.9991	0.0008	29.8800	29.9400	29.9000	1.0000	0.9980	0.9994	0.0009	-0.0011	0.0002
654	30.3119	1.0045	0.0004	30.1800	30.1900	30.1600	1.0044	1.0040	1.0050	-0.0001	-0.0004	0.0006
658	30.7403	1.0095	0.0003	30.4400	30.4500	30.4600	1.0099	1.0095	1.0092	0.0003	0.0000	-0.0003
662	31.1652	1.0133	0.0004	30.7700	30.7600	30.7400	1.0128	1.0132	1.0138	-0.0004	-0.0001	0.0005
666	31.5861	1.0156	0.0007	31.1200	31.1100	31.0700	1.0150	1.0153	1.0166	-0.0006	-0.0003	0.0010
670	32.0023	1.0149	0.0003	31.5400	31.5400	31.5200	1.0147	1.0147	1.0153	-0.0002	-0.0002	0.0004
674	32.4132	1.0058	0.0006	32.2400	32.2000	32.2400	1.0054	1.0066	1.0054	-0.0004	0.0008	-0.0004
678	32.8179	0.9994	0.0005	32.8300	32.8200	32.8600	0.9996	0.9999	0.9987	0.0002	0.0005	-0.0007
682	33.2158	0.9984	0.0004	33.2600	33.2600	33.2900	0.9987	0.9987	0.9978	0.0003	0.0003	-0.0006
686	33.6064	0.9942	0.0006	33.7900	33.8300	33.8300	0.9946	0.9934	0.9946	0.0004	-0.0008	0.0004
690	33.9888	0.9962	0.0007	34.1200	34.1500	34.0900	0.9962	0.9953	0.9970	0.0000	-0.0009	0.0009
694	34.3623	1.0018	0.0006	34.2800	34.3300	34.2900	1.0024	1.0009	1.0021	0.0006	-0.0009	0.0003
698	34.7264	1.0095	0.0002	34.4000	34.3900	34.4100	1.0095	1.0098	1.0092	0.0000	0.0003	-0.0003
702	35.0824	1.0176	0.0008	34.5000	34.4400	34.4900	1.0169	1.0187	1.0172	-0.0007	0.0011	-0.0004
706	35.4412	1.0275	0.0005	34.5100	34.4700	34.5000	1.0270	1.0282	1.0273	-0.0005	0.0007	-0.0002
710	35.8023	1.0364	0.0001	34.5400	34.5400	34.5500	1.0365	1.0365	1.0362	0.0001	0.0001	-0.0002
714	36.1634	1.0391	0.0004	34.8000	34.8200	34.7900	1.0392	1.0386	1.0395	0.0001	-0.0005	0.0004
718	36.5220	1.0403	0.0006	35.1100	35.1300	35.0800	1.0402	1.0396	1.0411	-0.0001	-0.0007	0.0008
722	36.8757	1.0422	0.0001	35.3800	35.3800	35.3900	1.0423	1.0423	1.0420	0.0001	0.0001	-0.0002
726	37.2220	1.0355	0.0001	35.9500	35.9400	35.9500	1.0354	1.0357	1.0354	-0.0001	0.0002	-0.0001
730	37.5585	1.0263	0.0001	36.6000	36.6000	36.5900	1.0262	1.0262	1.0265	-0.0001	-0.0001	0.0002
734	37.8828	1.0215	0.0005	37.0600	37.1000	37.1000	1.0222	1.0211	1.0211	0.0007	-0.0004	-0.0004

Table 6. (cont.) Comparison of NIST PR714 radiance measurements on the GSFC sphere and $\bar{F}(\lambda)$ to convert the PR714 readings to match the spectral radiance scale of the GSFC sphere (as calibrated with the 746/ISIC using the spectral irradiance scale of FEL lamp F269). At each wavelength (λ), corrected radiance $L(\lambda)$ is calculated as $L(\lambda) = \bar{F}(\lambda)L_{714}(\lambda)$, where, $L_{714}(\lambda)$ is the PR714 raw radiance ($P_i, i = 1, 3$) (multiplied by 100 to convert to units of $\mu\text{W cm}^{-2} \text{nm}^{-1} \text{sr}^{-1}$). This adjustment completes the correction for small aperture PR714 measurements. For large aperture PR714 measurements, however, $L(\lambda)$ must also be divided by the corresponding Average Ratio from Table 7. These results are based on the 746/ISIC file P930619B.DAT (19 June 1993, 1620 PDT) and the three PR714 data files: (P_i), subscript 1 refers to 36IGSP00.VR1 (19 June 1993, 1705 PDT), subscript 2 refers to 36IGSP00.VR2 (19 June 1993, 1715 PDT), and subscript 3 refers to 36IGSP00.VR3 (19 June 1993, 1725 PDT). The $\bar{F}(\lambda)$ and σ values are computed from these same data files. The symbol δ_i is the relative difference and is defined as $F_i - \bar{F}(\lambda)$.

λ [nm]	GSFC (L)	$\bar{F}(\lambda)$	σ	P_1	P_2	P_3	F_1	F_2	F_3	δ_1	δ_2	δ_3
738	38.1925	1.0127	0.0001	37.7100	37.7200	37.7100	1.0128	1.0125	1.0128	0.0001	-0.0002	0.0001
742	38.4849	0.9993	0.0001	38.5100	38.5200	38.5100	0.9993	0.9991	0.9993	0.0001	-0.0002	0.0001
746	38.7579	0.9939	0.0001	39.0000	38.9900	39.0000	0.9938	0.9940	0.9938	-0.0001	0.0002	-0.0001
750	39.0088	0.9933	0.0001	39.2700	39.2700	39.2800	0.9933	0.9933	0.9931	0.0001	0.0001	-0.0002
754	39.2545	0.9959	0.0005	39.3900	39.4400	39.4200	0.9966	0.9953	0.9958	0.0007	-0.0006	-0.0001
758	39.5110	1.0009	0.0005	39.4900	39.4900	39.4500	1.0005	1.0005	1.0015	-0.0003	-0.0003	0.0007
762	39.7747	1.0041	0.0009	39.6600	39.5800	39.6000	1.0029	1.0049	1.0044	-0.0012	0.0008	0.0003
766	40.0421	1.0033	0.0004	39.9300	39.9000	39.9000	1.0028	1.0036	1.0036	-0.0005	0.0003	0.0003
770	40.3094	1.0036	0.0001	40.1700	40.1600	40.1600	1.0035	1.0037	1.0037	-0.0002	0.0001	0.0001
774	40.5732	1.0060	0.0002	40.3400	40.3200	40.3300	1.0058	1.0063	1.0060	-0.0002	0.0002	0.0000
778	40.8299	1.0107	0.0008	40.3700	40.3800	40.4400	1.0114	1.0111	1.0096	0.0007	0.0004	-0.0011
782	41.0757	1.0164	0.0003	40.4000	40.4100	40.4300	1.0167	1.0165	1.0160	0.0003	0.0001	-0.0004
786	41.3073	1.0227	0.0000	40.3900	40.3900	40.3900	1.0227	1.0227	1.0227	0.0000	0.0000	0.0000
790	41.5209	1.0250	0.0001	40.5100	40.5100	40.5000	1.0250	1.0250	1.0252	-0.0001	-0.0001	0.0002
794	41.7130	1.0278	0.0001	40.5900	40.5800	40.5900	1.0277	1.0279	1.0277	-0.0001	0.0002	-0.0001
798	41.8800	1.0300	0.0004	40.6600	40.6400	40.6800	1.0300	1.0305	1.0295	0.0000	0.0005	-0.0005
802	42.0234	1.0276	0.0003	40.9000	40.8800	40.9100	1.0275	1.0280	1.0272	-0.0001	0.0004	-0.0003
806	42.1706	1.0189	0.0004	41.4100	41.3700	41.3800	1.0184	1.0194	1.0191	-0.0006	0.0004	0.0002
810	42.3241	1.0163	0.0002	41.6500	41.6300	41.6500	1.0162	1.0167	1.0162	-0.0002	0.0003	-0.0002
814	42.4815	1.0140	0.0005	41.9200	41.9000	41.8700	1.0134	1.0139	1.0146	-0.0006	-0.0001	0.0006
818	42.6403	1.0099	0.0001	42.2200	42.2200	42.2300	1.0100	1.0100	1.0097	0.0001	0.0001	-0.0002
822	42.7980	1.0091	0.0002	42.4200	42.4000	42.4100	1.0089	1.0094	1.0091	-0.0002	0.0002	0.0000
826	42.9520	1.0077	0.0002	42.6100	42.6300	42.6300	1.0080	1.0076	1.0076	0.0003	-0.0002	-0.0002
830	43.1000	1.0064	0.0003	42.8100	42.8400	42.8300	1.0068	1.0061	1.0063	0.0004	-0.0003	-0.0001
834	43.2394	1.0107	0.0003	42.7900	42.7600	42.7900	1.0105	1.0112	1.0105	-0.0002	0.0005	-0.0002
838	43.3676	1.0158	0.0004	42.7000	42.6700	42.7100	1.0156	1.0163	1.0154	-0.0002	0.0005	-0.0004
842	43.4823	1.0191	0.0004	42.6600	42.6500	42.6900	1.0193	1.0195	1.0186	0.0002	0.0004	-0.0005
846	43.5810	1.0246	0.0003	42.5300	42.5200	42.5500	1.0247	1.0250	1.0242	0.0001	0.0003	-0.0004
850	43.6610	1.0334	0.0005	42.2200	42.2700	42.2600	1.0341	1.0329	1.0332	0.0007	-0.0005	-0.0002
854	43.7388	1.0351	0.0005	42.2300	42.2800	42.2600	1.0357	1.0345	1.0350	0.0006	-0.0006	-0.0001

Table 6. (cont.) Comparison of NIST PR714 radiance measurements on the GSFC sphere and $\bar{F}(\lambda)$ to convert the PR714 readings to match the spectral radiance scale of the GSFC sphere (as calibrated with the 746/ISIC using the spectral irradiance scale of FEL lamp F269). At each wavelength (λ), corrected radiance $L(\lambda)$ is calculated as $L(\lambda) = \bar{F}(\lambda)L_{714}(\lambda)$, where, $L_{714}(\lambda)$ is the PR714 raw radiance ($P_i, i = 1, 3$) (multiplied by 100 to convert to units of $\mu\text{W cm}^{-2}\text{nm}^{-1}\text{sr}^{-1}$). This adjustment completes the correction for small aperture PR714 measurements. For large aperture PR714 measurements, however, $L(\lambda)$ must also be divided by the corresponding Average Ratio from Table 7. These results are based on the 746/ISIC file P930619B.DAT (19 June 1993, 1620 PDT) and the three PR714 data files: (P_i), subscript 1 refers to 36IGSP00.VR1 (19 June 1993, 1705 PDT), subscript 2 refers to 36IGSP00.VR2 (19 June 1993, 1715 PDT), and subscript 3 refers to 36IGSP00.VR3 (19 June 1993, 1725 PDT). The $\bar{F}(\lambda)$ and σ values are computed from these same data files. The symbol δ_i is the relative difference and is defined as $F_i - \bar{F}(\lambda)$.

λ [nm]	GSFC (L)	$\bar{F}(\lambda)$	σ	P_1	P_2	P_3	F_1	F_2	F_3	δ_1	δ_2	δ_3
858	43.8289	1.0402	0.0004	42.1200	42.1600	42.1300	1.0406	1.0396	1.0403	0.0004	-0.0006	0.0002
862	43.9268	1.0497	0.0003	41.8300	41.8600	41.8500	1.0501	1.0494	1.0496	0.0004	-0.0003	-0.0001
866	44.0276	1.0485	0.0004	42.0000	42.0000	41.9700	1.0483	1.0483	1.0490	-0.0002	-0.0002	0.0005
870	44.1266	1.0433	0.0001	42.3000	42.3000	42.2900	1.0432	1.0432	1.0434	-0.0001	-0.0001	0.0002
874	44.2189	1.0431	0.0003	42.4100	42.3800	42.3800	1.0427	1.0434	1.0434	-0.0005	0.0002	0.0002
878	44.3000	1.0440	0.0003	42.4300	42.4200	42.4500	1.0441	1.0443	1.0436	0.0001	0.0003	-0.0004
882	44.3649	1.0378	0.0000	42.7500	42.7500	42.7500	1.0378	1.0378	1.0378	0.0000	0.0000	0.0000
886	44.4090	1.0320	0.0003	43.0500	43.0200	43.0300	1.0316	1.0323	1.0320	-0.0004	0.0003	0.0001
890	44.4274	1.0294	0.0006	43.1800	43.1200	43.1700	1.0289	1.0303	1.0291	-0.0005	0.0008	-0.0003
894	44.4155	1.0229	0.0002	43.4100	43.4200	43.4300	1.0232	1.0229	1.0227	0.0002	0.0000	-0.0002
898	44.3685	1.0184	0.0001	43.5600	43.5700	43.5700	1.0186	1.0183	1.0183	0.0002	-0.0001	-0.0001
902	44.2880	1.0166	0.0003	43.5500	43.5600	43.5800	1.0169	1.0167	1.0162	0.0003	0.0001	-0.0004
906	44.2101	1.0145	0.0003	43.5900	43.5600	43.5900	1.0142	1.0149	1.0142	-0.0002	0.0005	-0.0002
910	44.1405	1.0125	0.0001	43.6000	43.6000	43.5900	1.0124	1.0124	1.0126	-0.0001	-0.0001	0.0002
914	44.0786	1.0122	0.0006	43.5800	43.5400	43.5200	1.0114	1.0124	1.0128	-0.0008	0.0002	0.0006
918	44.0238	1.0132	0.0004	43.4700	43.4500	43.4300	1.0127	1.0132	1.0137	-0.0005	0.0000	0.0005
922	43.9756	1.0137	0.0002	43.3700	43.3800	43.3900	1.0140	1.0137	1.0135	0.0002	0.0000	-0.0002
926	43.9333	1.0182	0.0004	43.1400	43.1300	43.1700	1.0184	1.0186	1.0177	0.0002	0.0004	-0.0005
930	43.8964	1.0235	0.0001	42.8900	42.8800	42.8900	1.0235	1.0237	1.0235	-0.0001	0.0002	-0.0001
934	43.8644	1.0302	0.0009	42.6200	42.5800	42.5300	1.0292	1.0302	1.0314	-0.0010	-0.0001	0.0011
938	43.8366	1.0349	0.0008	42.3200	42.3600	42.4000	1.0358	1.0349	1.0339	0.0009	0.0000	-0.0009
942	43.8125	1.0358	0.0004	42.2800	42.3000	42.3200	1.0362	1.0358	1.0353	0.0005	0.0000	-0.0005
946	43.7915	1.0383	0.0004	42.1700	42.1600	42.2000	1.0385	1.0387	1.0377	0.0002	0.0004	-0.0006
950	43.7731	1.0418	0.0005	42.0300	41.9900	42.0300	1.0415	1.0425	1.0415	-0.0003	0.0006	-0.0003
954	43.7565	1.0430	0.0010	41.9700	41.9000	41.9900	1.0426	1.0443	1.0421	-0.0004	0.0013	-0.0009
958	43.7414	1.0416	0.0008	42.0300	42.0000	41.9500	1.0407	1.0415	1.0427	-0.0009	-0.0002	0.0010
962	43.7270	1.0409	0.0004	42.0100	42.0300	41.9900	1.0409	1.0404	1.0414	0.0000	-0.0005	0.0005
966	43.7129	1.0406	0.0001	42.0100	42.0000	42.0100	1.0405	1.0408	1.0405	-0.0001	0.0002	-0.0001
970	43.6985	1.0425	0.0002	41.9100	41.9300	41.9100	1.0427	1.0422	1.0427	0.0002	-0.0003	0.0002
974	43.6831	1.0392	0.0002	42.0300	42.0300	42.0500	1.0393	1.0393	1.0388	0.0002	0.0002	-0.0003

Table 6. (cont.) Comparison of NIST PR714 radiance measurements on the GSFC sphere and $\bar{F}(\lambda)$ to convert the PR714 readings to match the spectral radiance scale of the GSFC sphere (as calibrated with the 746/ISIC using the spectral irradiance scale of FEL lamp F269). At each wavelength (λ), corrected radiance $L(\lambda)$ is calculated as $L(\lambda) = \bar{F}(\lambda)L_{714}(\lambda)$, where, $L_{714}(\lambda)$ is the PR714 raw radiance ($P_i, i = 1, 3$) (multiplied by 100 to convert to units of $\mu\text{W cm}^{-2} \text{nm}^{-1} \text{sr}^{-1}$). This adjustment completes the correction for small aperture PR714 measurements. For large aperture PR714 measurements, however, $L(\lambda)$ must also be divided by the corresponding Average Ratio from Table 7. These results are based on the 746/ISIC file P930619B.DAT (19 June 1993, 1620 PDT) and the three PR714 data files: (P_i), subscript 1 refers to 36IGSP00.VR1 (19 June 1993, 1705 PDT), subscript 2 refers to 36IGSP00.VR2 (19 June 1993, 1715 PDT), and subscript 3 refers to 36IGSP00.VR3 (19 June 1993, 1725 PDT). The $\bar{F}(\lambda)$ and σ values are computed from these same data files. The symbol δ_i is the relative difference and is defined as $F_i - \bar{F}(\lambda)$.

λ [nm]	GSFC (L)	$\bar{F}(\lambda)$	σ	P_1	P_2	P_3	F_1	F_2	F_3	δ_1	δ_2	δ_3
978	43.6662	1.0422	0.0010	41.8600	41.9500	41.8800	1.0431	1.0409	1.0426	0.0009	-0.0013	0.0004
982	43.6472	1.0490	0.0010	41.5900	41.5700	41.6600	1.0495	1.0500	1.0477	0.0004	0.0009	-0.0013
986	43.6256	1.0480	0.0008	41.6200	41.5900	41.6700	1.0482	1.0489	1.0469	0.0002	0.0009	-0.0010
990	43.6007	1.0463	0.0008	41.6300	41.6800	41.7100	1.0473	1.0461	1.0453	0.0010	-0.0002	-0.0009
994	43.5721	1.0498	0.0007	41.5300	41.5200	41.4700	1.0492	1.0494	1.0507	-0.0006	-0.0003	0.0009
998	43.5391	1.0499	0.0005	41.4800	41.4900	41.4400	1.0496	1.0494	1.0507	-0.0002	-0.0005	0.0007
1002	43.5011	1.0471	0.0004	41.5200	41.5600	41.5500	1.0477	1.0467	1.0470	0.0006	-0.0004	-0.0002
1006	43.4576	1.0494	0.0010	41.3600	41.4300	41.4500	1.0507	1.0489	1.0484	0.0013	-0.0004	-0.0009
1010	43.4081	1.0440	0.0002	41.5700	41.5900	41.5800	1.0442	1.0437	1.0440	0.0002	-0.0002	0.0000
1014	43.3518	1.0343	0.0009	41.9600	41.9100	41.8700	1.0332	1.0344	1.0354	-0.0011	0.0001	0.0010
1018	43.2883	1.0308	0.0020	42.0300	42.0700	41.8800	1.0299	1.0290	1.0336	-0.0009	-0.0018	0.0027
1022	43.2169	1.0336	0.0013	41.7800	41.8900	41.7700	1.0344	1.0317	1.0346	0.0008	-0.0018	0.0010
1026	43.1372	1.0289	0.0010	41.8700	41.9700	41.9400	1.0303	1.0278	1.0285	0.0014	-0.0010	-0.0003
1030	43.0484	1.0295	0.0027	41.6800	41.8100	41.9500	1.0328	1.0296	1.0262	0.0032	0.0001	-0.0033
1034	42.9502	1.0336	0.0020	41.4500	41.5600	41.6500	1.0362	1.0334	1.0312	0.0025	-0.0002	-0.0023
1038	42.8418	1.0347	0.0005	41.3800	41.4300	41.4100	1.0353	1.0341	1.0346	0.0006	-0.0006	-0.0001
1042	42.7227	1.0333	0.0049	41.6100	41.2900	41.1400	1.0267	1.0347	1.0385	-0.0064	0.0013	0.0050
1046	42.5923	1.0279	0.0014	41.4500	41.5000	41.3600	1.0276	1.0263	1.0298	-0.0003	-0.0015	0.0019
1050	42.4500	1.0314	0.0009	41.1300	41.2100	41.1300	1.0321	1.0301	1.0321	0.0006	-0.0013	0.0006
1054	42.2954	1.0442	0.0012	40.5400	40.4400	40.5400	1.0433	1.0459	1.0433	-0.0008	0.0016	-0.0008
1058	42.1277	1.0495	0.0015	40.0900	40.1100	40.2200	1.0508	1.0503	1.0474	0.0012	0.0007	-0.0020
1062	41.9465	1.0544	0.0039	39.9800	39.7400	39.6300	1.0492	1.0555	1.0585	-0.0049	0.0011	0.0039
1066	41.7511	1.0417	0.0069	40.4600	39.9100	39.8800	1.0319	1.0461	1.0469	-0.0094	0.0043	0.0051
1070	41.5410	1.0325	0.0029	40.1100	40.3800	40.2100	1.0357	1.0288	1.0331	0.0031	-0.0036	0.0006

Table 7. Ratios of large aperture radiances to small aperture radiances for the PR714, from paired measurements (taken in rapid succession) of the CHORS sphere at a fixed geometry, and the average ratio. To correct large aperture PR714 radiances, as initially calibrated using Table 6, simply divide by the average ratio (below) at each wavelength (λ).

Column		Large Aperture	Small Aperture	Date	Times [PDT]
		File	File		
1		test_002	test_001	18 June 1993	1810/1805
2		test_004	test_003	18 June 1993	1816/1815
3		36icsp11.Lr1	36icsp11.Lr0	19 June 1993	1046/1045
4		36icsp11.Lr3	36icsp11.Lr2	19 June 1993	1050/1048

λ [nm]	(1)	(2)	(3)	(4)	Average	λ [nm]	(1)	(2)	(3)	(4)	Average
382	1.1088	1.1028	1.1175	1.1162	1.1113	554	1.0352	1.0354	1.0356	1.0341	1.0351
386	1.0510	1.0637	1.0810	1.0590	1.0637	558	1.0333	1.0327	1.0340	1.0318	1.0329
390	1.0566	1.0732	1.0673	1.0977	1.0737	562	1.0316	1.0303	1.0310	1.0294	1.0306
394	1.0920	1.0665	1.0861	1.0726	1.0793	566	1.0283	1.0277	1.0279	1.0279	1.0280
398	1.0889	1.0860	1.0912	1.0664	1.0831	570	1.0324	1.0311	1.0313	1.0307	1.0314
402	1.0653	1.0608	1.0774	1.0624	1.0665	574	1.0355	1.0347	1.0334	1.0339	1.0344
406	1.0491	1.0484	1.0549	1.0465	1.0497	578	1.0420	1.0420	1.0427	1.0432	1.0425
410	1.0457	1.0478	1.0437	1.0442	1.0454	582	1.0481	1.0476	1.0485	1.0481	1.0481
414	1.0524	1.0567	1.0582	1.0552	1.0556	586	1.0459	1.0471	1.0482	1.0462	1.0469
418	1.0600	1.0592	1.0596	1.0639	1.0607	590	1.0391	1.0408	1.0392	1.0396	1.0397
422	1.0435	1.0455	1.0464	1.0428	1.0446	594	1.0325	1.0331	1.0340	1.0330	1.0331
426	1.0407	1.0419	1.0402	1.0394	1.0406	598	1.0273	1.0253	1.0279	1.0267	1.0268
430	1.0457	1.0459	1.0462	1.0469	1.0462	602	1.0265	1.0256	1.0264	1.0241	1.0257
434	1.0537	1.0548	1.0516	1.0513	1.0528	606	1.0281	1.0268	1.0281	1.0272	1.0276
438	1.0610	1.0572	1.0580	1.0587	1.0587	610	1.0304	1.0302	1.0295	1.0292	1.0298
442	1.0406	1.0380	1.0371	1.0395	1.0388	614	1.0342	1.0335	1.0348	1.0325	1.0338
446	1.0361	1.0369	1.0360	1.0326	1.0354	618	1.0420	1.0415	1.0428	1.0412	1.0419
450	1.0398	1.0406	1.0429	1.0381	1.0403	622	1.0422	1.0416	1.0436	1.0444	1.0430
454	1.0444	1.0414	1.0451	1.0419	1.0432	626	1.0387	1.0403	1.0407	1.0402	1.0400
458	1.0497	1.0484	1.0468	1.0509	1.0489	630	1.0366	1.0366	1.0396	1.0358	1.0371
462	1.0576	1.0569	1.0574	1.0592	1.0578	634	1.0326	1.0321	1.0354	1.0305	1.0326
466	1.0439	1.0426	1.0432	1.0430	1.0432	638	1.0300	1.0292	1.0317	1.0282	1.0298
470	1.0334	1.0357	1.0373	1.0355	1.0355	642	1.0284	1.0280	1.0298	1.0272	1.0283
474	1.0305	1.0333	1.0349	1.0337	1.0331	646	1.0326	1.0319	1.0342	1.0322	1.0327
478	1.0378	1.0373	1.0377	1.0354	1.0370	650	1.0339	1.0308	1.0345	1.0319	1.0328
482	1.0460	1.0449	1.0464	1.0442	1.0454	654	1.0349	1.0318	1.0333	1.0332	1.0333
486	1.0605	1.0585	1.0603	1.0587	1.0595	658	1.0367	1.0359	1.0392	1.0348	1.0367
490	1.0505	1.0500	1.0508	1.0506	1.0505	662	1.0343	1.0345	1.0371	1.0346	1.0351
494	1.0405	1.0405	1.0417	1.0411	1.0409	666	1.0348	1.0338	1.0358	1.0343	1.0347
498	1.0299	1.0304	1.0320	1.0302	1.0306	670	1.0381	1.0379	1.0391	1.0371	1.0380
502	1.0304	1.0292	1.0295	1.0282	1.0293	674	1.0341	1.0335	1.0350	1.0335	1.0340
506	1.0383	1.0387	1.0370	1.0365	1.0376	678	1.0297	1.0291	1.0290	1.0288	1.0292
510	1.0429	1.0410	1.0425	1.0415	1.0420	682	1.0330	1.0337	1.0335	1.0321	1.0331
514	1.0457	1.0450	1.0465	1.0467	1.0460	686	1.0330	1.0337	1.0333	1.0303	1.0326
518	1.0457	1.0468	1.0464	1.0451	1.0460	690	1.0322	1.0317	1.0337	1.0296	1.0318
522	1.0393	1.0393	1.0413	1.0394	1.0398	694	1.0327	1.0328	1.0320	1.0321	1.0324
526	1.0313	1.0276	1.0288	1.0284	1.0290	698	1.0344	1.0333	1.0335	1.0336	1.0337
530	1.0284	1.0277	1.0283	1.0276	1.0280	702	1.0317	1.0306	1.0327	1.0314	1.0316
534	1.0361	1.0341	1.0357	1.0336	1.0349	706	1.0298	1.0289	1.0311	1.0286	1.0296
538	1.0394	1.0384	1.0396	1.0376	1.0388	710	1.0278	1.0285	1.0309	1.0289	1.0290
542	1.0408	1.0418	1.0411	1.0401	1.0409	714	1.0255	1.0268	1.0270	1.0254	1.0262
546	1.0493	1.0499	1.0487	1.0495	1.0494	718	1.0254	1.0265	1.0275	1.0251	1.0261
550	1.0458	1.0449	1.0468	1.0461	1.0459	722	1.0328	1.0319	1.0333	1.0305	1.0321

Table 7. (cont.) Ratios of large aperture radiances to small aperture radiances for the PR714, from paired measurements (taken in rapid succession) of the CHORS sphere at a fixed geometry, and the average ratio. To correct large aperture PR714 radiances, as initially calibrated using Table 6, simply divide by the average ratio (below) at each wavelength (λ).

λ [nm]	(1)	(2)	(3)	(4)	Average	λ [nm]	(1)	(2)	(3)	(4)	Average
726	1.0335	1.0319	1.0336	1.0307	1.0324	898	1.0165	1.0163	1.0207	1.0168	1.0176
730	1.0354	1.0352	1.0368	1.0339	1.0353	902	1.0232	1.0235	1.0263	1.0230	1.0240
734	1.0417	1.0408	1.0424	1.0404	1.0413	906	1.0323	1.0341	1.0352	1.0305	1.0330
738	1.0438	1.0454	1.0461	1.0428	1.0445	910	1.0481	1.0475	1.0486	1.0442	1.0471
742	1.0462	1.0467	1.0480	1.0440	1.0462	914	1.0500	1.0510	1.0537	1.0501	1.0512
746	1.0487	1.0482	1.0492	1.0466	1.0482	918	1.0472	1.0482	1.0494	1.0473	1.0480
750	1.0413	1.0414	1.0448	1.0402	1.0419	922	1.0385	1.0409	1.0403	1.0363	1.0390
754	1.0285	1.0280	1.0302	1.0278	1.0286	926	1.0311	1.0350	1.0348	1.0310	1.0330
758	1.0207	1.0217	1.0226	1.0205	1.0214	930	1.0298	1.0277	1.0321	1.0268	1.0291
762	1.0302	1.0300	1.0316	1.0285	1.0301	934	1.0346	1.0355	1.0368	1.0329	1.0350
766	1.0294	1.0298	1.0330	1.0293	1.0304	938	1.0363	1.0368	1.0381	1.0320	1.0358
770	1.0245	1.0242	1.0259	1.0231	1.0244	942	1.0308	1.0327	1.0378	1.0320	1.0333
774	1.0215	1.0212	1.0233	1.0200	1.0215	946	1.0345	1.0313	1.0376	1.0354	1.0347
778	1.0230	1.0215	1.0235	1.0216	1.0224	950	1.0343	1.0350	1.0349	1.0364	1.0351
782	1.0254	1.0257	1.0290	1.0231	1.0258	954	1.0367	1.0380	1.0390	1.0366	1.0376
786	1.0299	1.0313	1.0327	1.0301	1.0310	958	1.0319	1.0347	1.0397	1.0362	1.0356
790	1.0333	1.0349	1.0334	1.0331	1.0337	966	1.0327	1.0358	1.0378	1.0374	1.0359
794	1.0382	1.0380	1.0401	1.0368	1.0383	970	1.0323	1.0351	1.0355	1.0363	1.0348
798	1.0407	1.0415	1.0421	1.0398	1.0410	974	1.0300	1.0335	1.0349	1.0316	1.0325
802	1.0394	1.0387	1.0417	1.0392	1.0398	978	1.0328	1.0291	1.0327	1.0299	1.0311
806	1.0354	1.0349	1.0375	1.0349	1.0357	982	1.0312	1.0324	1.0367	1.0312	1.0329
810	1.0339	1.0340	1.0366	1.0349	1.0348	986	1.0330	1.0310	1.0364	1.0359	1.0341
814	1.0336	1.0353	1.0370	1.0346	1.0351	990	1.0289	1.0308	1.0292	1.0301	1.0297
818	1.0306	1.0321	1.0314	1.0294	1.0309	994	1.0275	1.0279	1.0328	1.0274	1.0289
822	1.0320	1.0317	1.0332	1.0310	1.0320	998	1.0254	1.0320	1.0298	1.0236	1.0277
826	1.0327	1.0320	1.0360	1.0333	1.0335	1002	1.0260	1.0209	1.0315	1.0280	1.0266
830	1.0290	1.0288	1.0333	1.0291	1.0300	1006	1.0281	1.0275	1.0320	1.0293	1.0292
834	1.0298	1.0302	1.0329	1.0300	1.0307	1010	1.0319	1.0358	1.0347	1.0352	1.0344
838	1.0302	1.0322	1.0333	1.0314	1.0318	1014	1.0305	1.0346	1.0310	1.0277	1.0309
842	1.0296	1.0303	1.0324	1.0301	1.0306	1018	1.0294	1.0267	1.0368	1.0261	1.0298
846	1.0303	1.0294	1.0322	1.0294	1.0303	1022	1.0343	1.0328	1.0380	1.0328	1.0345
850	1.0333	1.0322	1.0350	1.0323	1.0332	1026	1.0367	1.0346	1.0340	1.0308	1.0340
854	1.0330	1.0324	1.0353	1.0322	1.0332	1030	1.0404	1.0370	1.0383	1.0341	1.0374
858	1.0311	1.0324	1.0340	1.0324	1.0325	1034	1.0372	1.0386	1.0409	1.0387	1.0388
862	1.0342	1.0369	1.0370	1.0342	1.0356	1038	1.0314	1.0300	1.0336	1.0339	1.0322
866	1.0363	1.0383	1.0396	1.0367	1.0377	1042	1.0356	1.0401	1.0297	1.0278	1.0333
870	1.0335	1.0353	1.0375	1.0346	1.0352	1046	1.0393	1.0351	1.0377	1.0360	1.0370
874	1.0333	1.0329	1.0363	1.0324	1.0337	1050	1.0448	1.0365	1.0362	1.0294	1.0367
878	1.0352	1.0354	1.0388	1.0344	1.0360	1054	1.0462	1.0363	1.0316	1.0300	1.0361
882	1.0330	1.0343	1.0360	1.0320	1.0338	1058	1.0325	1.0290	1.0325	1.0116	1.0264
886	1.0284	1.0309	1.0321	1.0289	1.0301	1062	1.0224	1.0278	1.0575	1.0309	1.0347
890	1.0265	1.0290	1.0294	1.0265	1.0279	1066	1.0161	1.0439	1.0249	1.0213	1.0266
894	1.0200	1.0207	1.0221	1.0198	1.0206	1070	1.0170	1.0162	1.0050	1.0284	1.0167

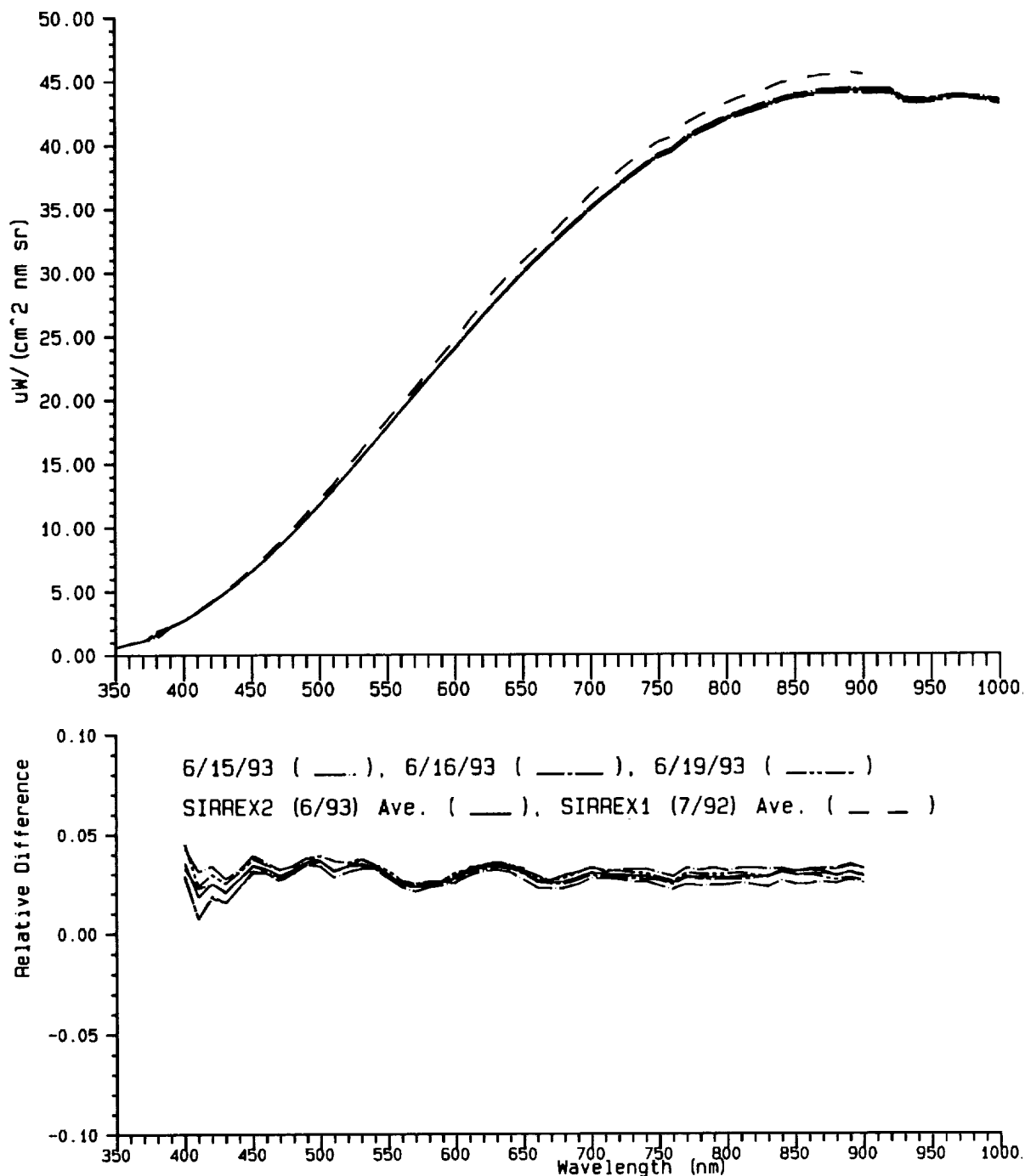


Fig. 17. Spectral radiance scale of the GSFC sphere, as referenced to FEL lamp F269 during SIRREX-2 in June 1993, and comparison to the sphere's spectral radiance scale during SIRREX-1 in July 1992. The top panel illustrates the average 746/ISIC F269 scale transfer (solid line) on 15, 16, and 19 June 1993, and compares it to scales of the individual days and SIRREX-1 (dashed lines). The bottom panel illustrates the relative change between July 1992, and June 1993. The radiance is in $\mu W cm^{-2} nm^{-1} sr^{-1}$ and wavelength is in nanometers.

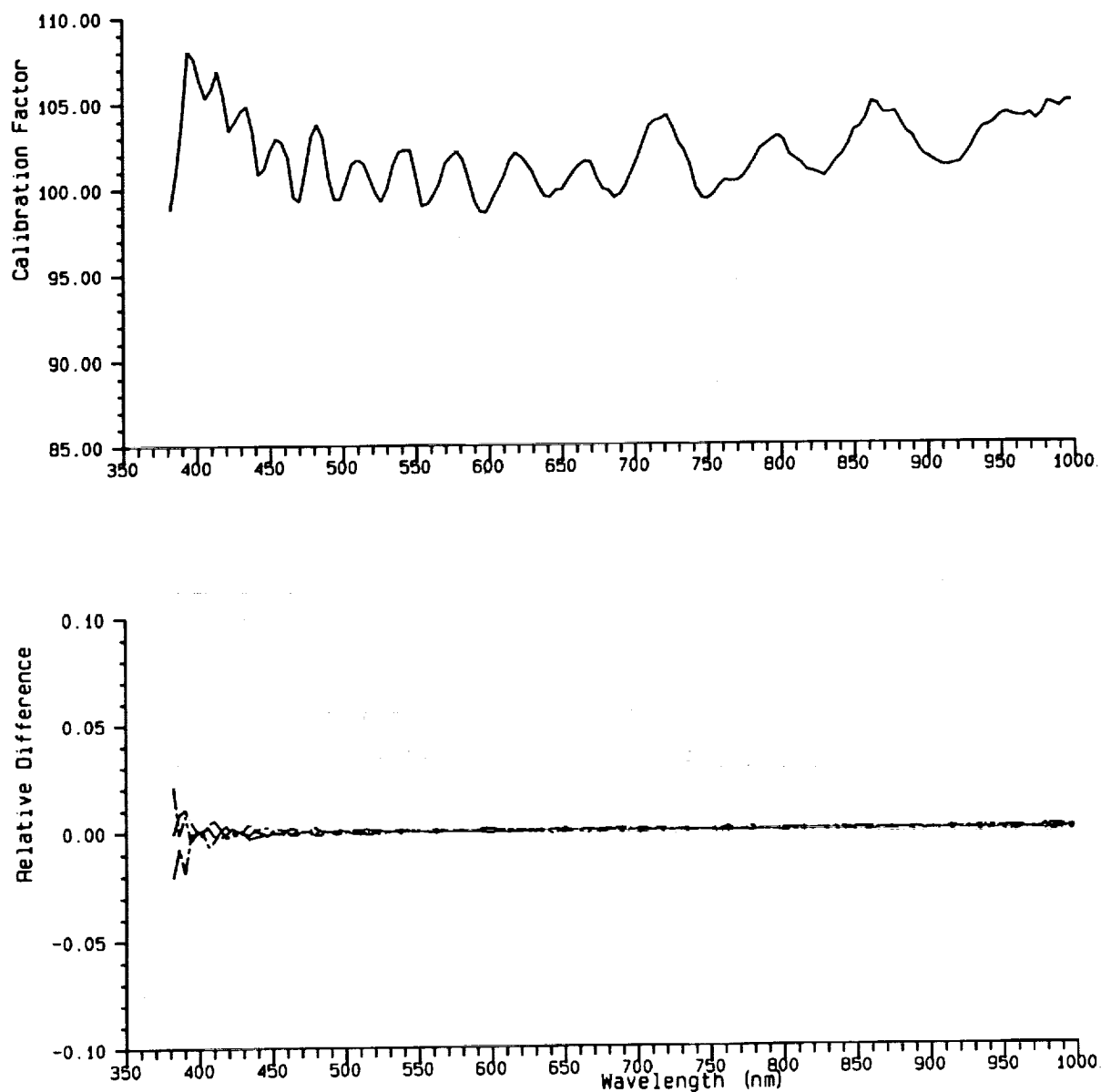


Fig. 18. Calibration factors to adjust the PR714 spectroradiometer raw radiance values to the spectral irradiance scale of the GSFC sphere, as referenced to FEL lamp F269 on 19 June 1993. The top panel illustrates the mean scaling ratio (solid line), derived from the average of three PR714 measurements at 1705, 1710, and 1725 PDT. The bottom panel illustrates the relative differences in the three individual measurements from the mean.

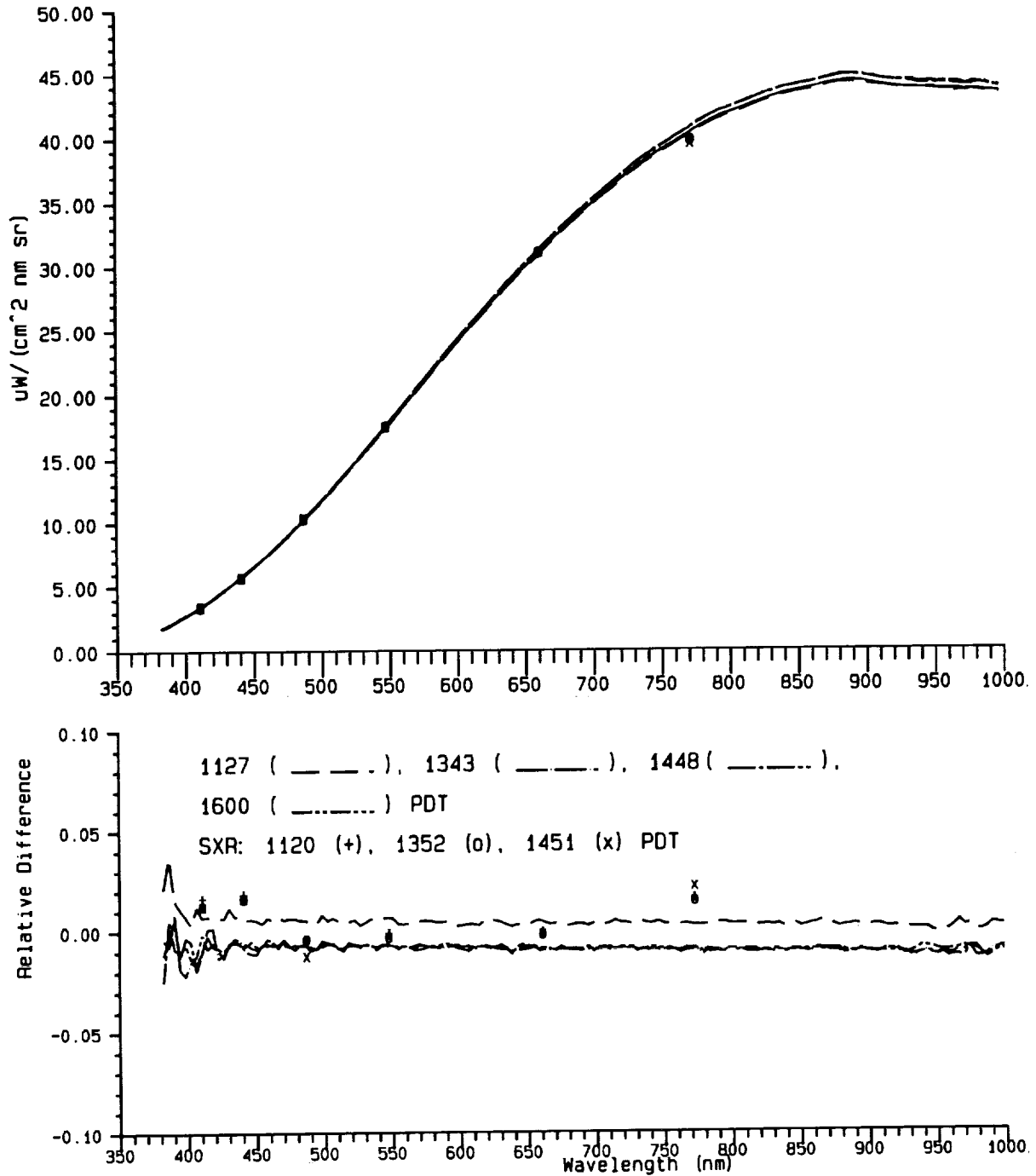


Fig. 19. Spectral radiance of the GSFC sphere measured with the PR714 at 1127 (before sphere warm-up), 1343, 1448, and 1600 PDT on 21 June 1993, compared with the radiance scale of the sphere on 19 June 1993 (referenced to FEL lamp F269) [solid curve in top panel]. Also shown are SXR radiances at 1120, 1352, and 1451 PDT (see above key). The top panel illustrates spectral radiance ($\mu W cm^{-2} nm^{-1} sr^{-1}$) of the sphere, and the bottom panel illustrates the departures of the PR714 and SXR radiances relative to the F269 calibrated scale.

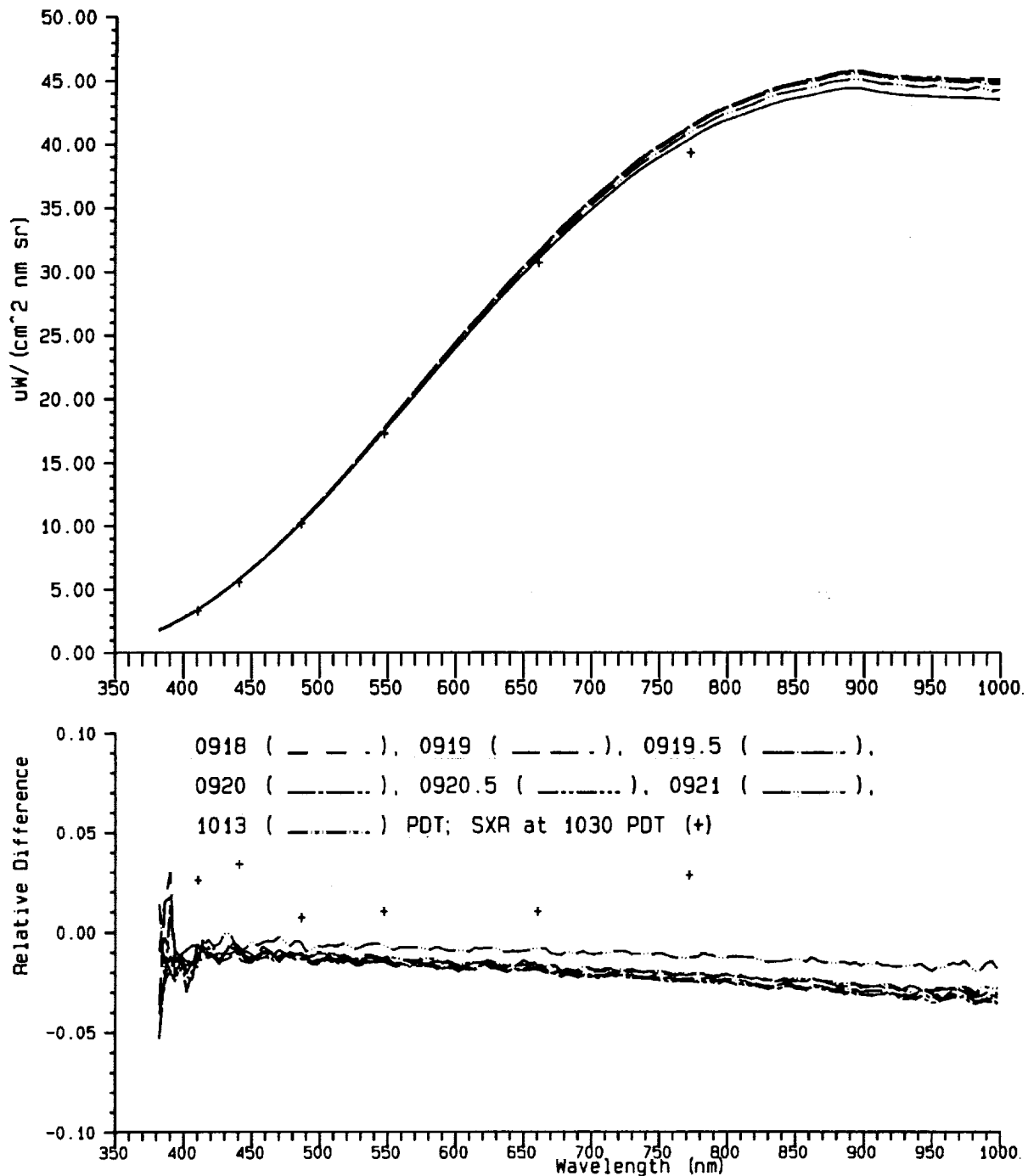


Fig. 20. Spectral radiance of the GSFC sphere measured with the PR714 at 0918, 0919, 0919.5, 0920, 0920.5, 0921, and 1013; and the SXR at 1030 PDT on 22 June 1993, compared with the radiance scale of the sphere on 19 June 1993 (referenced to FEL lamp F269) [solid curve in top panel]. The top panel illustrates spectral radiance ($\mu\text{W cm}^{-2} \text{ nm}^{-1} \text{ sr}^{-1}$) of the sphere, and the bottom panel illustrates the departures of the PR714 and SXR radiances relative to the F269 calibrated scale.

Table 8. GSFC sphere (16-lamps) spectral radiance [$\mu\text{W cm}^{-2}\text{nm}^{-1}\text{sr}^{-1}$] measured with the 746/ISC on 15, 16, and 19 June 1993; BSIXR, PR714 (small aperture) and the SXR on 19 June 1993 (dates and times are given in PDT).

λ [nm]	746 15 June 1255	746 15 June 1546	746 16 June 1420	746 16 June 1425	BSIXR 19 June 1549	746 19 June 1620	PR714 19 June 1705	PR714 19 June 1710	SXR 19 June 1715	PR714 19 June 1725
350	0.5695	0.5790	0.5687	0.5736		0.5618				
360	0.9062	0.9252	0.9159	0.9036		0.8775				
370	1.1211	1.1141	1.1277	1.1273		1.0993				
380	1.3705	1.3947	1.8130	1.8032		1.7590				
382							1.7718	1.7372		1.8113
386							2.0000	1.9687		1.9808
390	2.2058	2.2380	2.2371	2.2433		2.1992	2.2237	2.1602		2.2174
394							2.4340	2.4199		2.4124
398							2.6489	2.6467		2.6457
400	2.7180	2.7481	2.7585	2.7615		2.7134				
402							2.8779	2.8769		2.8716
406							3.1265	3.0991		3.1318
410	3.3607	3.3910	3.4436	3.4436		3.3873	3.3732	3.3658		3.3976
411									3.3627	
412					3.5346					
414							3.6438	3.6555		3.6609
418							3.9384	3.9542		3.9320
420	4.0937	4.1318	4.1572	4.1626		4.1114				
422							4.2499	4.2395		4.2364
426							4.5543	4.5574		4.5481
430	4.8674	4.9029	4.9276	4.9276		4.8796	4.8792	4.8719		4.8719
434							5.2244	5.1887		5.1982
438							5.5437	5.5292		5.5478
440	5.6914	5.7170	5.7446	5.7446		5.6977				
441									5.6778	
442							5.8818	5.8738		5.8919
443					5.8817					
446							6.2201	6.2242		6.2434
450	6.5592	6.5957	6.6116	6.6209		6.5719	6.5765	6.5847		6.5765
454							6.9336	6.9480		6.9315
458							7.3019	7.3174		7.3112
460	7.4966	7.5300	7.5385	7.5385		7.5054				
462							7.6900	7.6869		7.7093
466							8.0813	8.0923		8.1032
470	8.5058	8.5391	8.5517	8.5566		8.5065	8.5008	8.4969		8.5008
474							8.9191	8.9191		8.9100
478							9.3303	9.3283		9.3633
480	9.5562	9.5939	9.5900	9.5900		9.5541				
482							9.7576	9.7783		9.7804
486							10.2042	10.2135		10.2104
487									10.3087	
490	10.6519	10.6908	10.6884	10.6884	10.5514	10.6503	10.6511	10.6511		10.6511
494							11.1029	11.0830		11.1029
498							11.5502	11.5502		11.5303
500	11.7998	11.8327	11.8020	11.8020		11.7681				
502							11.9898	11.9898		11.9998
506							12.4403	12.4505		12.4606

Table 8. (cont.) GSFC sphere (16-lamps) spectral radiance [$\mu\text{W cm}^{-2}\text{nm}^{-1}\text{sr}^{-1}$] measured with the 746/ISC on 15, 16, and 19 June 1993; BSIXR, PR714 (small aperture) and the SXR on 19 June 1993 (dates and times are given in PDT).

λ [nm]	746 15 June 1255	746 15 June 1546	746 16 June 1420	746 16 June 1425	BSIXR 19 June 1549	746 19 June 1620	PR714 19 June 1705	PR714 19 June 1710	SXR 19 June 1715	PR714 19 June 1725
510	12.9692	13.0122	12.9733	12.9733		12.9043	12.9024	12.9228		12.9228
514							13.3852	13.3751		13.4055
518							13.8744	13.8543		13.8744
520	14.1459	14.1915	14.1517	14.1517		14.1203				
522							14.3620	14.3520		14.3421
526							14.8476	14.8476		14.8277
530	15.3414	15.4160	15.3895	15.3895		15.3351	15.3269	15.3369		15.3369
534							15.8254	15.8355		15.8254
538							16.3429	16.3225		16.3122
540	16.5806	16.6164	16.6103	16.6103		16.5811				
542							16.8137	16.8239		16.8341
546							17.3186	17.3288		17.3186
547									17.5083	
550	17.8322	17.8721	17.8702	17.8519		17.8008	17.8159	17.8159		17.8260
554							18.3209	18.3209		18.3109
558							18.8190	18.8091		18.8289
560	19.1194	19.1481	19.1278	19.1092		19.0763				
562							19.3095	19.3195		19.3394
566							19.8213	19.8413		19.8213
570	20.3682	20.4130	20.3689	20.3287		20.3339	20.3268	20.3370		20.3370
574							20.8459	20.8357		20.8357
578							21.3400	21.3502		21.3400
580	21.5949	21.6604	21.6390	21.5926		21.6055				
582							21.8387	21.8489		21.8489
586							22.3483	22.3382		22.3483
589					21.9760					
590	22.8519	22.9014	22.8665	22.8390		22.8386	22.8404	22.8404		22.8404
594							23.3182	23.3576		23.3182
598							23.8069	23.8464		23.7971
600	24.0965	24.0818	23.9879	23.9543		24.0476				
602							24.2903	24.3200		24.2803
606							24.7734	24.7834		24.7734
610	25.2593	25.3539	25.3109	25.2796		25.2491	25.2433	25.2735		25.2533
614							25.7256	25.7460		25.7358
618							26.2098	26.2200		26.2098
620	26.4666	26.5580	26.5293	26.4984		26.4662				
622							26.6816	26.6816		26.7019
626							27.1669	27.1669		27.1467
630	27.6240	27.7387	27.6890	27.6580		27.6353	27.6381	27.6180		27.6281
634							28.0881	28.1081		28.0781
638							28.5557	28.5457		28.5457
640	28.7435	28.8637	28.8097	28.7940		28.7625				
642							29.0137	28.9640		29.0236
646							29.4413	29.4313		29.4613
650	29.9002	30.0414	29.9494	29.9176		29.8720	29.8543	29.9143		29.8743
654							30.3152	30.3253		30.2951
656					29.2857					

Table 8. (cont.) GSFC sphere (16-lamps) spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{sr}^{-1}$] measured with the 746/ISC on 15, 16, and 19 June 1993; BSIXR, PR714 (small aperture) and the SXR on 19 June 1993 (dates and times are given in PDT).

λ [nm]	746 15 June 1255	746 15 June 1546	746 16 June 1420	746 16 June 1425	BSIXR 19 June 1549	746 19 June 1620	PR714 19 June 1705	PR714 19 June 1710	SXR 19 June 1715	PR714 19 June 1725
658							30.7301	30.7402		30.7503
660	30.9294	31.1314	31.0345	31.0021		30.9713				
661									31.0646	
662							31.1786	31.1685		31.1482
666							31.6064	31.5963		31.5556
670	32.0000	32.1426	32.0587	32.0422		31.9996	32.0090	32.0090		31.9887
674							32.4267	32.3864		32.4267
678							32.8112	32.8012		32.8412
680	32.9641	33.1867	33.1122	33.0784		33.0116				
682							33.2058	33.2058		33.2358
683					32.4052					
686							33.5931	33.6329		33.5931
690	33.9582	34.1771	34.0920	34.0574		33.9643	33.9888	34.0187		33.9589
694							34.3424	34.3925		34.3524
698							34.7265	34.7164		34.7365
700	34.9215	35.1189	35.0608	35.0251		34.9335				
702							35.1062	35.0451		35.0960
706							35.4583	35.4172		35.4481
710	35.8637	35.9892	35.9759	35.9206		35.8351	35.7990	35.7990		35.8093
714							36.1600	36.1808		36.1496
718							36.5253	36.5461		36.4941
720	36.6333	36.8248	36.7863	36.7476		36.6610				
722							36.8723	36.8723		36.8828
726							37.2255	37.2151		37.2255
730	37.4680	37.7114	37.6431	37.6040		37.5323	37.5619	37.5619		37.5516
734							37.8557	37.8965		37.8965
738							38.1889	38.1990		38.1889
740	38.2601	38.5079	38.4609	38.4233		38.3466				
742							38.4816	38.4916		38.4816
746							38.7612	38.7513		38.7612
750	38.9944	39.2685	39.1539	39.1352		39.0911	39.0055	39.0055		39.0154
754							39.2280	39.2778		39.2579
758							39.5244	39.5244		39.4843
760	39.4448	39.7114	39.6084	39.5702		39.5372				
762							39.8218	39.7415		39.7616
766							40.0622	40.0321		40.0321
770	40.2491	40.5983	40.4601	40.4404		40.3520	40.3162	40.3062		40.3062
772									39.8243	
774							40.5832	40.5631		40.5732
778							40.8028	40.8129		40.8735
780	40.8894	41.2262	41.0898	41.0694		40.9802				
782							41.0622	41.0723		41.0927
786							41.3073	41.3073		41.3073
790	41.3473	41.7220	41.5943	41.5731		41.4896	41.5244	41.5244		41.5141
794							41.7164	41.7061		41.7164
798							41.8802	41.8596		41.9008
800	41.8781	42.1978	42.0673	42.0673		41.9513				

Table 8. (cont.) GSFC sphere (16-lamps) spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{ sr}^{-1}$] measured with the 746/ISC on 15, 16, and 19 June 1993; BSIXR, PR714 (small aperture) and the SXR on 19 June 1993 (dates and times are given in PDT).

λ [nm]	746 15 June 1255	746 15 June 1546	746 16 June 1420	746 16 June 1425	BSIXR 19 June 1549	746 19 June 1620	PR714 19 June 1705	PR714 19 June 1710	SXR 19 June 1715	PR714 19 June 1725
802							42.0268	42.0062		42.0371
806							42.1943	42.1535		42.1637
810	42.2343	42.5718	42.4876	42.4419		42.3389	42.3310	42.3106		42.3310
814							42.5052	42.4849		42.4545
818							42.6371	42.6371		42.6472
820	42.5696	42.9463	42.7895	42.7661		42.7245				
822							42.8081	42.7880		42.7980
826							42.9385	42.9587		42.9587
830	42.9269	43.3314	43.0855	43.0855		43.0860	43.0831	43.1133		43.1033
834							43.2496	43.2192		43.2496
838							43.3742	43.3438		43.3844
840	43.3578	43.6301	43.4149	43.4149		43.4025				
842							43.4757	43.4655		43.5062
846							43.5775	43.5673		43.5980
850	43.6093	43.9025	43.6038	43.6038		43.6924	43.6301	43.6818		43.6715
854							43.7110	43.7628		43.7421
858							43.8115	43.8531		43.8219
860	43.8074	44.1101	43.8088	43.7633		43.8980				
862							43.9094	43.9409		43.9304
866							44.0383	44.0383		44.0068
870	43.9954	44.2655	43.9426	43.9426		44.1416	44.1299	44.1299		44.1195
874							44.2400	44.2087		44.2087
878							44.2965	44.2861		44.3174
880	44.1750	44.3471	44.0233	44.0020		44.2634				
882							44.3651	44.3651		44.3651
886							44.4263	44.3954		44.4057
890	44.2564	44.4155	44.0972	44.0557		44.3611	44.4516	44.3899		44.4414
894							44.4054	44.4156		44.4258
898							44.3615	44.3717		44.3717
900	44.1929	44.3433	44.0103	44.0103		44.2986				
902							44.2747	44.2848		44.3052
906							44.2203	44.1899		44.2203
910	44.1242	44.3453	44.0169	44.0169		44.2983	44.1437	44.1437		44.1336
914							44.1125	44.0721		44.0518
918							44.0442	44.0240		44.0037
920	44.1719	44.3762	44.0164	44.0164		44.3338				
922							43.9655	43.9756		43.9857
926							43.9264	43.9163		43.9570
930	43.4524	43.6897	43.2975	43.3748		43.6906	43.9001	43.8898		43.9001
934							43.9093	43.8680		43.8165
938							43.7953	43.8367		43.8781
940	43.3325	43.5025	43.1880	43.2652		43.5814				
942							43.7919	43.8126		43.8334
946							43.7847	43.7743		43.8158
950	43.3742	43.5726	43.2727	43.3115		43.6117	43.7868	43.7452		43.7868
954							43.7739	43.7009		43.7947
958							43.7797	43.7485		43.6964

Table 8. (cont.) GSFC sphere (16-lamps) spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{sr}^{-1}$] measured with the 746/ISC on 15, 16, and 19 June 1993; BSIXR, PR714 (small aperture) and the SXR on 19 June 1993 (dates and times are given in PDT).

λ [nm]	746 15 June 1255	746 15 June 1546	746 16 June 1420	746 16 June 1425	BSIXR 19 June 1549	746 19 June 1620	PR714 19 June 1705	PR714 19 June 1710	SXR 19 June 1715	PR714 19 June 1725
960	43.5945	43.8139	43.4892	43.5483		43.8137				
962							43.7270	43.7478		43.7061
966							43.7164	43.7060		43.7164
970	43.6390	43.9286	43.6107	43.6309		43.8425	43.6916	43.7124		43.6916
974							43.6763	43.6763		43.6971
978							43.6282	43.7220		43.6490
980	43.5462	43.8103	43.5576	43.5786		43.7280				
982							43.6296	43.6086		43.7030
986							43.6186	43.5872		43.6710
990	43.3930	43.7351	43.4785	43.5005		43.5994	43.5554	43.6077		43.6391
994							43.5965	43.5860		43.5336
998							43.5494	43.5599		43.5074
1000	43.1760	43.5026	43.3572	43.4044		43.4356				
1002							43.4768	43.5187		43.5083
1006							43.4015	43.4750		43.4960
1010							43.3974	43.4183		43.4079
1014							43.4001	43.3484		43.3070
1018							43.3262	43.3674		43.1716
1022							43.1825	43.2962		43.1722
1026							43.0788	43.1817		43.1508
1030							42.9116	43.0455		43.1896
1034							42.8436	42.9572		43.0503
1038							42.8142	42.8660		42.8453
1042							42.9956	42.6650		42.5100
1046							42.6060	42.6574		42.5135
1050							42.4227	42.5052		42.4227
1054							42.3302	42.2258		42.3302
1058							42.0753	42.0962		42.2117
1062							42.1545	41.9015		41.7855
1066							42.1452	41.5723		41.5410
1070							41.4140	41.6927		41.5172

Table 9. GSFC sphere (16-lamps) spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{ sr}^{-1}$] measured with the PR714 (small aperture) spectroradiometer on 19 and 21 June 1993 (date and time given in PDT). The spectrum listed for 1127 PDT on 21 June 1993 was measured shortly after the sphere lamps were turned on, without allowing time for warmup.

λ [nm]	SXR 21 June 1120	PR714 21 June 1127	PR714 21 June 1343	SXR 21 June 1352	PR714 21 June 1448	SXR 21 June 1451	PR714 21 June 1600
382		1.7352	1.7807		1.7935		1.8162
386		1.9091	1.9979		1.9878		1.9717
390		2.1665	2.1821		2.1873		2.2195
394		2.3951	2.4664		2.4534		2.4469
398		2.6274	2.7049		2.6554		2.6640
402		2.8663	2.9183		2.8907		2.9141
406		3.0812	3.1697		3.1792		3.1570
410		3.3552	3.4134		3.4145		3.3838
411	3.3631			3.3771		3.3778	
414		3.6267	3.6491		3.6609		3.6844
418		3.9120	3.9352		3.9700		3.9648
422		4.2126	4.2974		4.2799		4.2768
426		4.5231	4.6042		4.6125		4.5969
430		4.8175	4.9095		4.9022		4.9032
434		5.1646	5.2202		5.2328		5.2265
438		5.4961	5.5664		5.5706		5.5768
441	5.6631			5.6781		5.6785	
442		5.8486	5.9182		5.9383		5.9262
446		6.1918	6.2778		6.2970		6.2606
450		6.5437	6.6358		6.6522		6.6276
454		6.9099	6.9882		6.9820		6.9840
458		7.2619	7.3379		7.3605		7.3543
462		7.6533	7.7338		7.7379		7.7501
466		8.0345	8.1580		8.1470		8.1450
470		8.4512	8.5415		8.5316		8.5555
474		8.8605	8.9837		8.9777		8.9827
478		9.2829	9.4046		9.4252		9.4035
482		9.7182	9.8396		9.8344		9.8417
486		10.1527	10.2743		10.2794		10.2794
487	10.3151			10.3182		10.4033	
490		10.6108	10.7518		10.7518		10.7316
494		11.0532	11.1923		11.1923		11.1923
498		11.4508	11.6198		11.5999		11.6297
502		11.9295	12.0701		12.0601		12.0701
506		12.3693	12.5317		12.5215		12.5215
510		12.8516	13.0244		13.0244		13.0244
514		13.3243	13.5070		13.5171		13.4968
518		13.8039	13.9449		13.9549		13.9650
522		14.2722	14.4518		14.4419		14.4518
526		14.7980	14.9468		14.9568		14.9568
530		15.2669	15.4368		15.4368		15.4368
534		15.7342	15.9470		15.9368		15.9368
538		16.2305	16.4757		16.4655		16.4552
542		16.7216	16.9466		16.9466		16.9364
546		17.2062	17.4413		17.4515		17.4311

Table 9. (cont.) GSFC sphere (16-lamps) spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{sr}^{-1}$] measured with the PR714 (small aperture) spectroradiometer on 19 and 21 June 1993 (date and time given in PDT). The spectrum listed for 1127 PDT on 21 June 1993 was measured shortly after the sphere lamps were turned on, without allowing time for warmup.

λ [nm]	SXR 21 June 1120	PR714 21 June 1127	PR714 21 June 1343	SXR 21 June 1352	PR714 21 June 1448	SXR 21 June 1451	PR714 21 June 1600
547	17.4880			17.5274		17.5194	
550		17.7052	17.9468		17.9468		17.9569
554		18.2516	18.4792		18.4594		18.4495
558		18.7596	18.9578		18.9578		18.9677
562		19.2497	19.4789		19.4689		19.4789
566		19.7410	20.0018		20.0119		19.9717
570		20.2355	20.4791		20.5197		20.4689
574		20.7338	20.9885		21.0191		20.9885
578		21.2378	21.5136		21.5034		21.5136
582		21.7472	22.0217		22.0116		22.0116
586		22.2477	22.5393		22.5192		22.4991
590		22.7312	23.0191		23.0191		22.9894
594		23.2491	23.5155		23.5155		23.5056
598		23.7576	24.0238		24.0041		23.9844
602		24.2307	24.5186		24.4888		24.5086
606		24.6935	25.0233		24.9633		24.9933
610		25.1728	25.4647		25.4647		25.4949
614		25.6647	25.9492		25.9390		25.9187
618		26.0771	26.4139		26.4037		26.4241
622		26.5390	26.8954		26.8954		26.9158
626		27.0250	27.4002		27.3799		27.3799
630		27.5070	27.8803		27.8198		27.8501
634		28.0080	28.3483		28.3383		28.3283
638		28.4860	28.8742		28.8543		28.8344
642		28.9142	29.2226		29.2624		29.2823
646		29.3614	29.6510		29.6810		29.7209
650		29.8044	30.1541		30.1041		30.1541
654		30.1746	30.5663		30.5563		30.5362
658		30.5787	31.0229		31.0431		30.9926
661	31.0331			31.0728		31.0599	
662		31.0368	31.4319		31.4623		31.4319
666		31.4845	31.8603		31.8806		31.8705
670		31.8872	32.3135		32.2932		32.3135
674		32.3261	32.6681		32.7083		32.7083
678		32.7413	33.1210		33.1310		33.1310
682		33.1260	33.5154		33.5253		33.5154
686		33.4937	33.9013		33.9311		33.9311
690		33.8792	34.2976		34.3175		34.2976
694		34.2723	34.6429		34.6830		34.6329
698		34.6053	35.0596		35.0394		35.0798
702		34.9942	35.4114		35.4013		35.3809
706		35.3350	35.7666		35.7460		35.7357
710		35.6746	36.1306		36.0995		36.1514
714		35.9833	36.4925		36.5029		36.5029
718		36.3796	36.8374		36.8582		36.8374

Table 9. (cont.) GSFC sphere (16-lamps) spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{ sr}^{-1}$] measured with the PR714 (small aperture) spectroradiometer on 19 and 21 June 1993 (date and time given in PDT). The spectrum listed for 1127 PDT on 21 June 1993 was measured shortly after the sphere lamps were turned on, without allowing time for warmup.

λ [nm]	SXR 21 June 1120	PR714 21 June 1127	PR714 21 June 1343	SXR 21 June 1352	PR714 21 June 1448	SXR 21 June 1451	PR714 21 June 1600
722		36.7369	37.2058		37.2163		37.1954
726		37.1012	37.5569		37.5569		37.5362
730		37.4182	37.9211		37.9416		37.9211
734		37.7229	38.2541		38.2234		38.2438
738		38.0573	38.5535		38.5737		38.5332
742		38.3417	38.8414		38.8513		38.8114
746		38.5922	39.1190		39.1488		39.1091
750		38.8863	39.3929		39.3929		39.3631
754		39.1384	39.6463		39.6363		39.6064
758		39.3942	39.8947		39.9047		39.8947
762		39.6612	40.1732		40.2134		40.1833
766		39.9117	40.4033		40.4535		40.4334
770		40.1958	40.6775		40.6976		40.7076
772	39.8051			39.8703		39.8574	
774		40.4726	40.9454		40.9756		40.9957
778		40.7219	41.3182		41.2475		41.2374
782		40.9605	41.4992		41.5297		41.4585
786		41.1641	41.7163		41.7368		41.7061
790		41.3706	41.9344		41.9549		41.9446
794		41.5519	42.1686		42.1583		42.1480
798		41.7360	42.2716		42.2716		42.2716
802		41.9035	42.4378		42.4275		42.4481
806		42.0313	42.5917		42.5917		42.6019
810		42.1988	42.7782		42.7782		42.7375
814		42.3531	42.9209		42.9514		42.8804
818		42.5362	43.1118		43.1017		43.0613
822		42.6870	43.2522		43.2320		43.2623
826		42.8377	43.4122		43.3920		43.4021
830		43.0026	43.5762		43.5762		43.5259
834		43.1182	43.6943		43.6741		43.6741
838		43.2930	43.8415		43.8618		43.8313
842		43.3636	43.9445		43.9547		43.9445
846		43.4546	44.0181		44.0386		44.0079
850		43.5888	44.1158		44.1055		44.0952
854		43.6385	44.2078		44.1975		44.1768
858		43.6971	44.3004		44.3004		44.2484
862		43.7624	44.3293		44.3503		44.3712
866		43.8285	44.4472		44.4577		44.4891
870		43.9943	44.5889		44.5472		44.5681
874		44.1148	44.6781		44.6468		44.6677
878		44.2339	44.7976		44.7245		44.7559
882		44.2821	44.8321		44.8944		44.8113
886		44.3128	44.9010		44.9216		44.9010
890		44.3075	44.9355		44.9149		44.9149
894		44.3236	44.8657		44.8555		44.8759

Table 9. (cont.) GSFC sphere (16-lamps) spectral radiance [$\mu\text{W cm}^{-2}\text{nm}^{-1}\text{sr}^{-1}$] measured with the PR714 (small aperture) spectroradiometer on 19 and 21 June 1993 (date and time given in PDT). The spectrum listed for 1127 PDT on 21 June 1993 was measured shortly after the sphere lamps were turned on, without allowing time for warmup.

λ [nm]	SXR 21 June 1120	PR714 21 June 1127	PR714 21 June 1343	SXR 21 June 1352	PR714 21 June 1448	SXR 21 June 1451	PR714 21 June 1600
898		44.2800	44.8605		44.8605		44.8401
902		44.1933	44.7830		44.7728		44.7627
906		44.0986	44.7174		44.6971		44.7072
910		44.0526	44.6195		44.6297		44.6094
914		44.0316	44.5377		44.5579		44.5174
918		43.9632	44.4901		44.5205		44.4698
922		43.9148	44.4521		44.4723		44.4419
926		43.8653	44.4356		44.4254		44.4763
930		43.8694	44.4221		44.4630		44.3914
934		43.8474	44.4347		44.4141		44.3214
938		43.8160	44.3541		44.3541		44.2196
942		43.7816	44.2891		44.2995		44.2062
946		43.8366	44.3350		44.2934		44.1896
950		43.8285	44.3390		44.3390		44.2244
954		43.7634	44.2432		44.2849		44.2119
958		43.7589	44.2901		44.3422		44.2068
962		43.6437	44.2474		44.2890		44.1745
966		43.5291	44.1223		44.2888		44.1327
970		43.6186	44.0982		44.2650		44.1816
974		43.5828	44.0920		44.0920		44.0816
978		43.6803	44.2639		44.1180		44.0555
982		43.6715	44.2485		44.1751		44.1751
986		43.5976	44.1740		44.2579		44.2264
990		43.4717	44.0367		44.1517		44.0890
994		43.4601	43.9954		44.0479		44.0164
998		43.4445	43.9274		44.0114		43.9589
1002		43.3512	44.0946		43.8747		43.9166
1006		43.4015	44.0941		43.9052		43.9157
1010		43.4496	44.0551		43.8881		43.9090
1014		43.2656	43.8035		43.8035		43.8448
1018		43.2953	43.7179		43.8829		43.6870
1022		43.1722	43.6063		43.7717		43.6787
1026		42.9347	43.6447		43.6652		43.6344
1030		43.0558	43.7765		43.6117		43.5294
1034		43.0606	43.6498		43.4534		43.4017
1038		42.6590	43.3833		43.3522		43.3212
1042		42.5616	43.1299		43.3573		43.0473
1046		42.3079	42.8527		43.0275		43.0583
1050		42.2680	42.8250		42.7631		42.8147
1054		42.6122	42.7270		42.6644		42.8941
1058		42.4846	42.5475		42.8204		42.9359
1062		41.7222	42.4919		43.0613		42.7766
1066		41.8327	42.3431		42.2493		42.3639
1070		41.3727	42.0025		41.7547		41.9922

Table 10. GSFC sphere (16-lamps) spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{ sr}^{-1}$] measured with the PR714 (small aperture) spectroradiometer on 22 and 23 June 1993, and the BSIXR and SXR on 22 June 1993 (date and time given in PDT). The 22 June PR714 scans were made at different lens focus settings. PR714 lens focus settings are given (last row of header); units are in meters.

λ [nm]	PR714 0918 0.7 m	PR714 0919 1.0 m	PR714 0919 2.0 m	PR714 0920 5.0 m	PR714 0920 ∞	PR714 0921 0.3 m	SXR 0926 0.7 m	PR714 1013	BSIXR 1430†	PR714 1450†
382	1.7886	1.8370	1.8666	1.7866	1.8449	1.7895		1.7480		1.8063
386	1.9525	1.9555	2.0262	2.0070	2.0353	1.9878		2.0303		1.9848
390	2.1613	2.1342	2.2258	2.2424	2.1706	2.2216		2.2435		2.2008
394	2.4837	2.4632	2.4685	2.4448	2.4567	2.4556		2.4826		2.4599
398	2.6941	2.6758	2.6855	2.6801	2.6780	2.6758		2.6780		2.6758
402	2.9215	2.9322	2.9343	2.9609	2.9385	2.9003		2.9162		2.9152
406	3.1686	3.1781	3.1644	3.1792	3.1929	3.1391		3.1634		3.1760
410	3.4134	3.3976	3.4240	3.4240	3.4092	3.4007		3.4378		3.4177
411							3.3313			
412									3.5567	
414	3.6844	3.6962	3.7026	3.6790	3.6844	3.6780		3.6673		3.6726
418	3.9817	3.9848	3.9890	3.9774	3.9922	3.9553		3.9690		3.9637
422	4.2902	4.2943	4.2912	4.2912	4.2736	4.2705		4.2943		4.2902
426	4.6188	4.6157	4.6000	4.6146	4.6240	4.5793		4.6250		4.6250
430	4.9200	4.9409	4.9252	4.9220	4.9262	4.8760		4.9252		4.9116
434	5.2328	5.2684	5.2600	5.2391	5.2401	5.2066		5.2317		5.2286
438	5.5706	5.5954	5.5913	5.5882	5.5923	5.5757		5.5861		5.5923
442	5.9293	5.9454	5.9474	5.9514	5.9656	5.9363		5.9383		5.9333
443									5.8771	
446	6.3112	6.2880	6.3031	6.3132	6.3224	6.2758		6.3213		6.3031
450	6.6768	6.6512	6.6716	6.6573	6.6768	6.6062		6.6727		6.6430
454	7.0139	7.0345	7.0160	7.0293	7.0201	6.9830		7.0139		7.0201
458	7.3852	7.3831	7.3811	7.4037	7.3903	7.3461		7.3615		7.3708
462	7.7746	7.7654	7.7664	7.7847	7.7929	7.7287		7.7634		7.7542
466	8.1829	8.1819	8.1898	8.2067	8.1868	8.1281		8.1789		8.1460
470	8.5872	8.5733	8.6240	8.6011	8.6150	8.5187		8.6011		8.5733
474	9.0171	9.0110	9.0211	9.0060	9.0191	8.9565		9.0221		8.9918
478	9.4448	9.4479	9.4324	9.4582	9.4592	9.4046		9.4417		9.4066
482	9.8811	9.8883	9.8769	9.8811	9.9039	9.8136		9.8769		9.8479
486	10.3237	10.3237	10.3237	10.3237	10.3443	10.2588		10.3134		10.2959
490	10.7920	10.7719	10.7820	10.8021	10.8021	10.7518		10.7820	10.4941	10.7518
494	11.2222	11.2321	11.2619	11.2719	11.2619	11.1923		11.2321		11.2222
498	11.6794	11.6695	11.7093	11.7291	11.6993	11.6198		11.6595		11.6595
502	12.1404	12.1203	12.1505	12.1505	12.1605	12.0802		12.1103		12.0902
506	12.6129	12.5926	12.6027	12.6230	12.6331	12.5317		12.5824		12.5621
510	13.0854	13.0854	13.0956	13.0956	13.1058	13.0041		13.0549		13.0448
514	13.5679	13.5476	13.5983	13.5983	13.5882	13.4765		13.5476		13.5374
518	14.0456	14.0254	14.0456	14.0758	14.0657	13.9449		14.0254		13.9952
522	14.5417	14.5317	14.5616	14.5417	14.5616	14.4518		14.5317		14.4718
526	15.0560	15.0560	15.0659	15.0560	15.0858	14.9667		15.0362		14.9766
530	15.5568	15.5468	15.5668	15.5768	15.5868	15.4468		15.5368		15.4768
534	16.0280	16.0280	16.0483	16.0686	16.0686	15.9267		16.0078		15.9774
538	16.5369	16.5472	16.5676	16.5676	16.5778	16.4246		16.5165		16.5063
542	17.0489	17.0285	17.0796	17.0694	17.0694	16.9160		17.0285		16.9773
546	17.5435	17.5435	17.5640	17.5742	17.5742	17.4311		17.5435		17.4720
547							17.3073			

† Measurements taken on 23 June 1993; all other measurements were taken on 22 June 1993.

Table 10. (cont.) GSFC sphere (16-lamps) spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{ sr}^{-1}$] measured with the PR714 (small aperture) spectroradiometer on 22 and 23 June 1993, and the BSIXR and SXR on 22 June 1993 (date and time given in PDT). The 22 June PR714 scans were made at different lens focus settings. PR714 lens focus settings are given (last row of header); units are in meters.

λ [nm]	PR714 0918 0.7 m	PR714 0919 1.0 m	PR714 0919 2.0 m	PR714 0920 5.0 m	PR714 0920 ∞	PR714 0921 0.3 m	SXR 0926 0.7 m	PR714 1013	BSIXR 1430†	PR714 1450†
550	18.0575	18.0374	18.0575	18.0978	18.0978	17.9468		18.0474		17.9669
554	18.5980	18.5980	18.6178	18.6178	18.6277	18.4792		18.5485		18.4990
558	19.0866	19.1064	19.1064	19.1163	19.1362	18.9677		19.0668		19.0073
562	19.5885	19.6084	19.6283	19.6283	19.6383	19.4689		19.5885		19.5187
566	20.1222	20.1222	20.1523	20.1723	20.1623	19.9818		20.1021		20.0319
570	20.6414	20.6313	20.6414	20.6719	20.6719	20.4892		20.6211		20.5298
574	21.1210	21.1515	21.1617	21.1923	21.1719	20.9987		21.1312		21.0293
578	21.6464	21.6771	21.7077	21.6873	21.7077	21.5238		21.6260		21.5647
582	22.1641	22.1742	22.1946	22.2047	22.2251	22.0319		22.1336		22.0726
586	22.6901	22.6700	22.7202	22.7604	22.7303	22.5091		22.6499		22.5594
589									21.9647	
590	23.1979	23.1880	23.2376	23.2376	23.2575	23.0291		23.1880		23.0589
594	23.6831	23.6831	23.7325	23.7522	23.7522	23.5451		23.6634		23.5549
598	24.2111	24.1914	24.2308	24.2505	24.2505	24.0337		24.1815		24.0435
602	24.7469	24.6973	24.7370	24.7767	24.7667	24.5186		24.6973		24.5384
606	25.2031	25.2031	25.1931	25.2231	25.2331	25.0033		25.1532		25.0233
610	25.6660	25.6660	25.7163	25.7063	25.7365	25.5050		25.6459		25.5352
614	26.1320	26.1320	26.2235	26.2133	26.2032	25.9390		26.1117		26.0000
618	26.6078	26.6078	26.6691	26.6486	26.6589	26.4343		26.6180		26.4649
622	27.0889	27.0380	27.1093	27.1296	27.1296	26.8954		27.0787		26.9158
626	27.6030	27.5928	27.6537	27.6131	27.6537	27.3697		27.5523		27.4205
630	28.0721	28.0821	28.0922	28.1326	28.1225	27.8501		28.0519		27.9106
634	28.5585	28.5585	28.5685	28.6286	28.6186	28.3583		28.5385		28.3984
638	29.0534	29.0534	29.1230	29.1230	29.1131	28.8344		29.0235		28.8742
642	29.5011	29.4513	29.5309	29.5409	29.5309	29.2723		29.5011		29.3419
646	29.9307	29.9007	30.0105	29.9906	29.9906	29.7309		29.9207		29.7709
650	30.3739	30.3639	30.4438	30.4338	30.4538	30.1641		30.3039		30.1341
654	30.7974	30.8275	30.8978	30.8476	30.8878	30.5864		30.7773		30.5965
656									29.4180	
658	31.2551	31.2046	31.2853	31.2954	31.3156	30.9926		31.2248		31.0632
662	31.6853	31.7055	31.6954	31.7562	31.7663	31.4218		31.6751		31.5535
666	32.1244	32.1345	32.1752	32.1650	32.2259	31.8400		32.1142		31.9111
670	32.5672	32.5672	32.6585	32.6585	32.6687	32.3338		32.5266		32.3642
674	32.9698	33.0201	33.0603	33.1006	33.0704	32.7686		32.9497		32.7385
678	33.4509	33.4608	33.4808	33.5608	33.5508	33.1910		33.4509		33.1610
682	33.8748	33.8248	33.9247	33.9147	33.9247	33.5353		33.8448		33.5653
683									32.4566	
686	34.2393	34.2393	34.2990	34.3387	34.3089	33.9609		34.2493		33.9609
690	34.6761	34.6662	34.7060	34.7558	34.7558	34.3474		34.6363		34.3474
694	35.0336	35.0537	35.0737	35.1038	35.1138	34.6930		34.9635		34.7331
698	35.3725	35.4230	35.4836	35.4634	35.5038	35.1000		35.3422		35.1504
702	35.7371	35.7879	35.8592	35.8388	35.8795	35.4725		35.7574		35.4928
706	36.1159	36.1262	36.2289	36.2084	36.2598	35.8180		36.1365		35.8796
710	36.5038	36.4623	36.5763	36.5970	36.6074	36.1825		36.5038		36.2550
714	36.8250	36.8250	36.9081	36.9393	36.9601	36.5340		36.8666		36.5964
718	37.2015	37.2223	37.2639	37.3367	37.3159	36.8686		37.2223		36.9206

† Measurements taken on 23 June 1993; all other measurements were taken on 22 June 1993.

Table 10. (cont.) GSFC sphere (16-lamps) spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{ sr}^{-1}$] measured with the PR714 (small aperture) spectroradiometer on 22 and 23 June 1993, and the BSIXR and SXR on 22 June 1993 (date and time given in PDT). The 22 June PR714 scans were made at different lens focus settings. PR714 lens focus settings are given (last row of header); units are in meters.

λ [nm]	PR714 0918 0.7 m	PR714 0919 1.0 m	PR714 0919 2.0 m	PR714 0920 5.0 m	PR714 0920 ∞	PR714 0921 0.3 m	SXR 0926 0.7 m	PR714 1013	BSIXR 1430†	PR714 1450†
722	37.5602	37.6123	37.6435	37.6748	37.6748	37.2267		37.5602		37.2996
726	37.9296	37.9711	38.0228	38.0125	38.0642	37.5776		37.9607		37.6708
730	38.2597	38.2700	38.3624	38.4239	38.4137	37.9724		38.3008		37.9929
734	38.6218	38.6422	38.7341	38.7546	38.7546	38.2949		38.6422		38.3153
738	38.9687	38.9687	39.0497	39.0700	39.0902	38.6143		38.9586		38.6143
742	39.2710	39.2411	39.3610	39.3610	39.3810	38.8913		39.2610		38.8913
746	39.5265	39.5464	39.5961	39.6457	39.6756	39.1886		39.5265		39.1985
750	39.7803	39.8200	39.8895	39.8995	39.9491	39.4227		39.7604		39.4426
754	40.0745	40.0745	40.1542	40.1741	40.2139	39.6861		40.0446		39.6761
758	40.3551	40.3651	40.4051	40.4452	40.4952	39.9848		40.3251		39.9647
762	40.6452	40.6150	40.7154	40.7456	40.7556	40.2837		40.6452		40.2335
766	40.8849	40.8949	40.9852	41.0253	41.0253	40.5438		40.8749		40.5036
770	41.1794	41.1794	41.2596	41.2797	41.3098	40.8281		41.1492		40.8080
772							39.3340			
774	41.4585	41.4283	41.5088	41.5591	41.5692	41.0762		41.4384		41.0360
778	41.6821	41.6922	41.8135	41.8438	41.8539	41.3385		41.7023		41.3182
782	41.9362	41.9566	42.0379	42.0887	42.1090	41.5195		41.9362		41.5805
786	42.2072	42.1970	42.2481	42.3095	42.3402	41.7777		42.2072		41.8288
790	42.4264	42.4469	42.5187	42.5392	42.5699	42.0164		42.4469		42.0369
794	42.6208	42.6413	42.7236	42.7441	42.7955	42.2405		42.6208		42.2303
798	42.7763	42.7763	42.8793	42.8587	42.9102	42.4261		42.7557		42.4158
802	42.9721	42.9310	43.0235	43.0749	43.0955	42.5303		42.9413		42.5611
806	43.1215	43.1012	43.1827	43.2642	43.2744	42.6834		43.1215		42.6936
810	43.2355	43.2660	43.3473	43.4185	43.4185	42.8391		43.2660		42.8798
814	43.4482	43.4482	43.5293	43.6003	43.6206	43.0122		43.4482		43.0426
818	43.6369	43.6369	43.7581	43.7682	43.7884	43.1724		43.6268		43.1724
822	43.7870	43.7769	43.9081	43.9384	43.9687	43.3733		43.7870		43.3228
826	43.9563	43.9865	44.0974	44.1175	44.1478	43.5532		43.9462		43.4928
830	44.1600	44.1398	44.2606	44.2707	44.3310	43.7473		44.1298		43.6568
834	44.2704	44.2805	44.3917	44.4321	44.4422	43.8661		44.3209		43.7853
838	44.4306	44.4306	44.5221	44.6033	44.5932	44.0040		44.4205		43.9735
842	44.5253	44.5253	44.5967	44.6782	44.6782	44.1075		44.4948		44.0464
846	44.6534	44.6226	44.7149	44.7661	44.7456	44.1820		44.6329		44.1411
850	44.7359	44.7256	44.8496	44.8806	44.9012	44.2502		44.6739		44.2502
854	44.7978	44.8185	44.9324	44.9531	44.9945	44.3424		44.7564		44.3217
858	44.9037	44.9141	45.0701	45.0701	45.1117	44.4772		44.8725		44.4460
862	44.9171	44.9486	45.1060	45.1585	45.1165	44.4867		44.9486		44.5392
866	45.0973	45.0658	45.2021	45.2441	45.2441	44.6464		45.0868		44.5940
870	45.2149	45.2253	45.3297	45.3818	45.4027	44.7872		45.2045		44.6515
874	45.3562	45.3353	45.4501	45.4709	45.5126	44.8867		45.3040		44.8033
878	45.4762	45.4658	45.5806	45.6224	45.6224	44.9855		45.4031		44.9333
882	45.5170	45.5793	45.6208	45.7038	45.6831	45.0293		45.5274		44.9463
886	45.5821	45.6131	45.6853	45.7369	45.7885	45.0661		45.5408		45.0042
890	45.6149	45.6355	45.7076	45.7693	45.7899	45.1414		45.5635		45.0384
894	45.5818	45.5715	45.6943	45.7966	45.7557	45.0908		45.5613		44.9782

† Measurements taken on 23 June 1993; all other measurements were taken on 22 June 1993.

Table 10. (cont.) GSFC sphere (16-lamps) spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{sr}^{-1}$] measured with the PR714 (small aperture) spectroradiometer on 22 and 23 June 1993, and the BSIXR and SXR on 22 June 1993 (date and time given in PDT). The 22 June PR714 scans were made at different lens focus settings. PR714 lens focus settings are given (last row of header); units are in meters.

λ [nm]	PR714 0918 0.7 m	PR714 0919 1.0 m	PR714 0919 2.0 m	PR714 0920 5.0 m	PR714 0920 ∞	PR714 0921 0.3 m	SXR 0926 0.7 m	PR714 1013	BSIXR 1430†	PR714 1450†
898	45.6040	45.5836	45.7160	45.7669	45.7567	45.1151		45.5530		44.9522
902	45.5048	45.4743	45.5963	45.6776	45.6878	44.9762		45.4845		44.9355
906	45.4275	45.4174	45.5188	45.6000	45.6203	44.9304		45.4478		44.8391
910	45.3587	45.3384	45.4397	45.5308	45.5206	44.8220		45.3283		44.7411
914	45.3373	45.2968	45.3981	45.4487	45.4487	44.8211		45.2361		44.6693
918	45.2500	45.2905	45.4121	45.3513	45.4019	44.7535		45.1790		44.6522
922	45.2022	45.2225	45.3340	45.3340	45.3137	44.7359		45.1617		44.5737
926	45.2196	45.2196	45.3112	45.3621	45.3825	44.6901		45.1687		44.5985
930	45.1590	45.1386	45.3126	45.2716	45.3842	44.6473		45.1897		44.5654
934	45.1044	45.0528	45.2692	45.2589	45.3207	44.5995		45.1765		44.5892
938	45.0992	45.0475	45.1923	45.3269	45.2958	44.5714		45.2130		44.4990
942	45.0245	45.0866	45.1073	45.2213	45.2213	44.5066		45.1177		44.4134
946	45.0514	45.1449	45.0929	45.1864	45.2902	44.5738		45.0722		44.5011
950	45.0995	45.0995	45.1204	45.2245	45.3079	44.6307		45.0370		44.5786
954	45.0046	44.9837	45.2340	45.1193	45.3175	44.5248		45.0463		44.4310
958	44.9880	44.9984	45.2067	45.2276	45.2172	44.5297		45.0088		44.4776
962	44.9760	44.9760	45.0801	45.1946	45.1529	44.4451		44.9760		44.3515
966	44.9548	44.9340	44.9652	45.1421	45.0692	44.3824		44.9548		44.3200
970	44.9322	45.0364	44.9635	45.1407	45.1094	44.4109		44.9322		44.3692
974	44.8817	44.9025	45.0065	45.0688	45.1208	44.2998		44.8817		44.2583
978	44.9935	44.9935	45.0560	45.1082	45.2124	44.4203		44.9101		44.3160
982	44.9933	45.0668	45.1926	45.1717	45.2241	44.5003		44.9933		44.4268
986	44.9601	45.0229	45.1173	45.1592	45.1382	44.4465		44.8343		44.3417
990	44.8841	44.9260	45.0201	45.0620	45.1248	44.2773		44.8004		44.2668
994	44.8457	44.8038	44.9507	45.0242	45.0872	44.2054		44.7933		44.1949
998	44.8198	44.8933	44.9668	45.0928	45.1033	44.3264		44.7673		44.2004
1002	44.6915	44.7648	44.8067	44.9324	44.9324	44.2936		44.5973		44.0946
1006	44.8182	44.8391	44.8811	44.9756	44.9336	44.2200		44.6922		44.2410
1010	44.8485	44.8485	44.8798	44.8903	44.9425	44.1804		44.7546		44.2013
1014	44.6206	44.5999	44.9309	44.7033	44.9205	44.0310		44.6102		44.0207
1018	44.5220	44.6354	44.7900	44.7591	44.8312	44.2024		44.5117		43.7489
1022	44.6089	44.6606	44.6192	44.7019	44.6606	44.0508		44.4228		44.0094
1026	44.5706	44.4781	44.6221	44.7353	44.5706	43.9739		44.5295		43.8299
1030	44.5075	44.3839	44.6928	44.8163	44.7340	43.9412		44.7134		43.9206
1034	44.3216	44.2493	44.5594	44.6110	44.7144	43.6188		44.2286		43.7325
1038	44.2421	44.0351	44.4904	44.4904	44.3559	43.7144		44.2007		43.6730
1042	44.0909	44.1529	43.9152	43.9876	44.2252	43.5019		44.2046		42.8716
1046	43.8601	44.0040	43.8601	43.8087	44.1170	43.5311		43.9115		42.7911
1050	43.8564	43.9595	43.8152	43.9595	43.9802	43.4645		43.3201		42.7940
1054	43.9905	43.8338	43.8756	43.9383	44.0740	43.4162		43.4371		43.2178
1058	43.6180	43.2297	43.6180	43.9014	43.9959	42.8834		43.5761		43.0933
1062	43.0613	43.2195	43.5358	43.9259	43.5779	42.8610		43.4092		43.0297
1066	43.1972	42.9889	43.3847	43.4368	43.4368	42.3118		43.3014		42.6660
1070	42.6530	43.1589	42.9627	43.2312	43.1383	42.1264		43.0040		42.1367

† Measurements taken on 23 June 1993; all other measurements were taken on 22 June 1993.

(Tables 9, 10, and 12). In general, the SXR radiances on all days are in closer agreement with the 746/ISIC reading of 19 June than they are with concurrent measurements made with the PR714.

The radiance levels of the GSFC sphere may be varied by selecting the number of lamps with which it is illuminated. Variations in radiance scales for 1–16 lamps were measured with the 746/ISIC on 15 June 1993 (Table 11), and with the PR714 and SXR on 22 June 1993 (Tables 12 and 13). The two sets of radiance scales for the 16 levels of illumination are illustrated in Fig. 21. As with the other PR714 measurements on 22 June 1993, the measured radiance levels of the GSFC sphere were about 3% higher than those measured with the 746/ISIC on 15 June 1993. PR714 radiances also exceeded the SXR radiances at all wavelengths by amounts ranging from 1–5%.

3.2.2 The BSI Sphere

The spectral radiance of the BSI sphere, with one lamp and open aperture, was measured with the 746/ISIC (F269) on 17 June 1993, the PR714 on 24 June, the BSIXR on 17 and 23 June, and the SXR on 23 June (Table 14 and Fig. 22). The 17 June BSIXR radiances exceeded the 17 June 746/ISIC (F269) scale of this sphere by 0.5–2.5%, but on 23 June, the BSIXR radiances indicate decreases in spectral radiance to within less than 1% of the 17 June 746/ISIC (F269) scale. The PR714 radiance spectra for the BSI sphere on 24 June exceeded the 17 June 746/ISIC (F269) scale by approximately 2% at 400 nm, increasing to 4% at 900 nm, and then decreasing to 2% (1,000 nm). SXR radiances of the BSI sphere on 23 June exceeded 746/ISIC (17 June) radiances by 3.5–6.5% and PR714 (24 June) radiances by approximately 3.5–7%.

3.2.3 The CHORS Sphere

At the outset of SIRREX-2, the CHORS sphere was configured with four 125 W tungsten-halogen lamps. Initial measurements with the 746/ISIC indicated that the sphere's radiance levels in this configuration were undesirably low. Therefore, four new 275 W lamps were installed on 17 June, and the CHORS sphere was turned on to season the lamps overnight. The spectral radiance of the sphere was measured at approximately hourly intervals with the BSIXR on the afternoon of 18 June 1993, with a follow-up BSIXR measurement at 1100 PDT on 19 June 1993. In addition to the BSIXR measurements on 18–19 June, the radiance scale of the CHORS sphere was measured with the PR714 on 18, 19, and 23 June 1993; and the SXR on 18 and 19 June, and was calibrated relative to lamp F269 with the 746/ISIC on 19 June 1993.

Calibrated spectral radiances for the CHORS sphere, as measured with these instruments, are listed in Tables 15–16. Figure 23 compares all of the above measurements of the CHORS sphere radiance scale. The 746/ISIC and PR714 values all show repeatable variations in the spectral

radiance with wavelength (Fig. 23, top panel), which represent undesirable line structures. This structure has been smoothed differently by the two radiometers, resulting in very large spikes in the relative differences (Fig. 23, bottom panel) as referenced to the 746/ISIC measurements. The analysis is compounded by the fact that the PR714 calibration factors (Fig. 18 and Table 6) depend strongly on wavelength.

The BSIXR (18–19 June) and the 746/ISIC (19 June) measurements of the CHORS sphere are compared separately in Fig. 24, and agree within 2%. Again, this disagreement is possibly attributable to the different spectral resolution of the two instruments when attempting to measure a source with structure. In Fig. 25, the BSIXR, SXR, and PR714 measurements from 18 June 1993, and the 746/ISIC spectrum of 19 June 1993 are compared. The BSIXR and PR714 data agree within 1–2% on 18 June; both of these instruments indicate lower overall spectral radiance levels, by up to 3% (neglecting spikes associated with the line resolution mismatch) from the 746/ISIC (F269) radiance scale of 19 June 1993. Figure 26 illustrates the same comparison for BSIXR, SXR, and PR714 data on 19 June, with almost the same results. Figure 27 compares the PR714 spectral radiance measurements of the CHORS sphere on 23 June with its 746/ISIC (F269) scale of 19 June. In this subset of the data, within-day variability between PR714 radiance measurements is significantly larger than on the previous days (3% versus 1% previously), and the apparent radiance of the sphere is shifted 5–7% higher. It was observed from the log sheets that the measurements on 23 June correspond to the closest distance between the PR714 and CHORS sphere, and the largest viewing angle (20° from normal). These variations of response with either distance or angle would indicate either out-of-field stray light sensitivity of the PR714, or inhomogeneity in the sphere. However, measurements of this sphere at two angles on 18 June agreed within less than 1%. Variation of PR714 sensitivity with room temperature could be another possible explanation.

Measurements of the CHORS sphere with the SXR on 19 June exceed 746/ISIC (19 June) measurements by 0.25–2% and with the PR714 (18–19 June) measurements by 0.25–4%.

3.2.4 The UCSB Sphere

Spectral radiance of the UCSB sphere, illuminated with FEL lamp F303 at 50 cm through a 50.8 cm entrance aperture, was measured with the 746/ISIC (F269), the PR714, and the SXR on 21 June 1993. The spectral radiance of the sphere with a 2.54 cm entrance aperture was also measured on this day with the PR714. The results of these measurements are listed in Table 17 and are illustrated in Fig. 28. Between wavelengths of 430–1,000 nm, the PR714 radiances are less than those measured with the 746/ISIC (F269) by approximately 5% (430 nm) to 10%

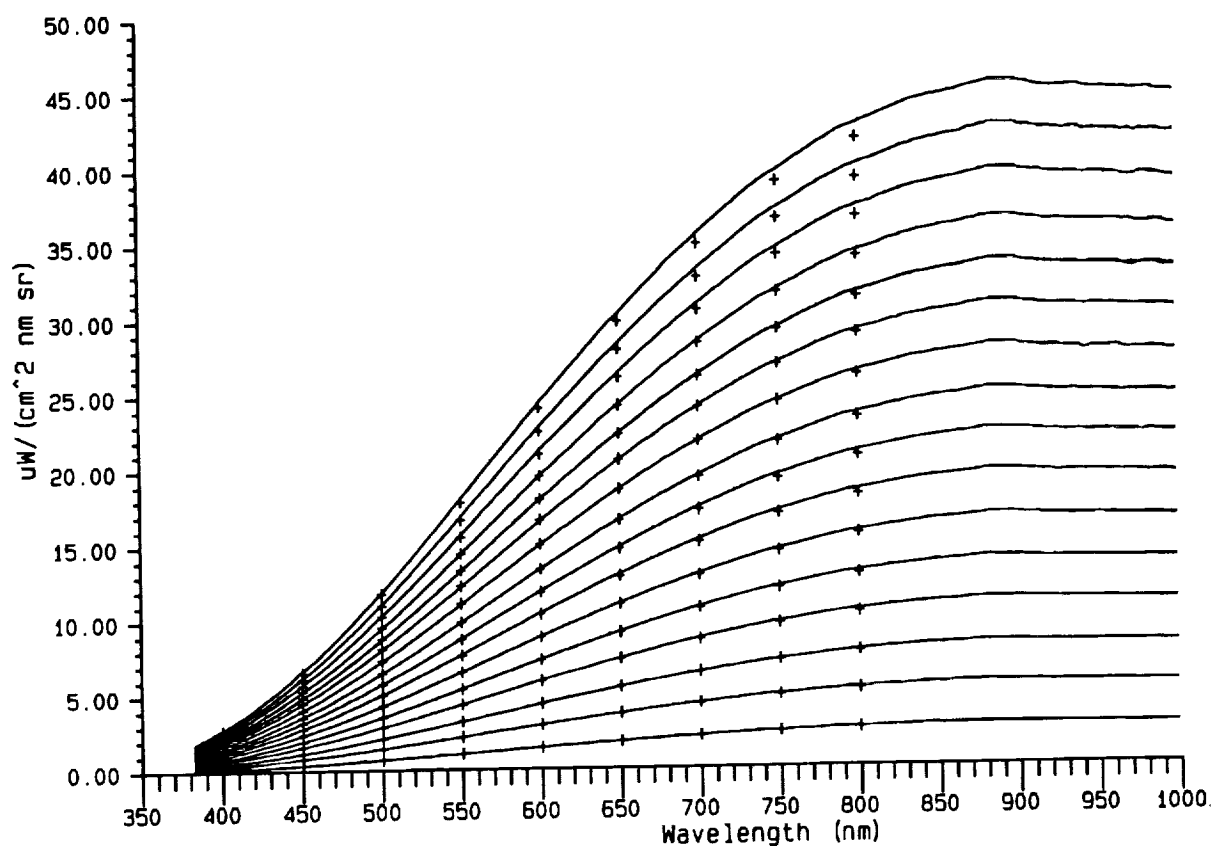


Fig. 21. Spectral radiance ($\mu\text{W cm}^{-2} \text{ nm}^{-1} \text{ sr}^{-1}$) of the GSFC sphere, with 1-16 lamps, measured with the PR714 (23 June 1993) (solid curves of increasing magnitude) and with the 746/ISIC (15 June 1993) at 50 nm intervals.

Table 11. GSFC sphere spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{ sr}^{-1}$], with intensity varied from 1–16 lamps, measured with the 746/ISIC on 15 June 1993 (date and time are given in PDT). (Top line of the header indicates the number of lamps turned on at one time.)

λ [nm]	1 1347	2 1344	3 1341	4 1338	5 1333	6 1331	7 1329	8 1327
400	0.1302	0.2622	0.3807	0.5241	0.8146	0.9980	1.1605	1.3212
450	0.3891	0.7999	1.1714	1.5863	1.9537	2.3931	2.7969	3.1947
500	0.7011	1.4371	2.1297	2.8780	3.5495	4.3055	5.0499	5.7560
550	1.0710	2.1979	3.2416	4.3751	5.3980	6.5385	7.6651	8.7398
600	1.4598	2.9706	4.3986	5.9253	7.3437	8.8673	10.4004	11.8602
650	1.8066	3.6971	5.4857	7.3672	9.1379	11.0313	12.8829	14.7104
700	2.1221	4.3249	6.4302	8.6162	10.7115	12.8941	15.1103	17.2257
750	2.3820	4.8417	7.2060	9.6445	12.0089	14.4685	16.9387	19.2678
800	2.5669	5.2045	7.7506	10.3716	12.9135	15.5845	18.1680	20.7515

Table 11. (cont.) GSFC sphere spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{ sr}^{-1}$], with intensity varied from 1–16 lamps, measured with the 746/ISIC on 15 June 1993 (date and time are given in PDT). (Top line of the header indicates the number of lamps turned on at one time.)

λ [nm]	9 1347	10 1344	11 1341	12 1338	13 1333	14 1331	15 1329	16 1327
400	1.4913	1.6954	1.8826	2.0357	2.2114	2.3740	2.5384	2.7161
450	3.6102	4.0724	4.5171	4.8916	5.3129	5.7224	6.1203	6.5592
500	6.5081	7.3408	8.1198	8.7990	9.5549	10.2917	11.0131	11.8036
550	9.8872	11.1313	12.3097	13.3396	14.4454	15.5513	16.6572	17.8322
600	13.3869	15.0444	16.6381	18.0086	19.5386	21.0366	22.5347	24.0965
650	16.5979	18.6352	20.6126	22.3203	24.2078	26.0953	27.9528	29.8403
700	19.4083	21.8259	24.0757	26.1239	28.3401	30.5563	32.7053	34.9215
750	21.7380	24.4200	26.8902	29.2193	31.6895	34.1598	36.5594	39.0297
800	23.3351	26.1686	28.9188	31.3773	34.0442	36.6694	39.2529	41.8781

Table 12. GSFC sphere spectral radiance [$\mu\text{W cm}^{-2}\text{nm}^{-1}\text{sr}^{-1}$], with intensity varied from 1–8 lamps, measured with the PR714 (small aperture) spectroradiometer and the SXR on 22 June 1993 (date and time are given in PDT). (The top line of the table header indicates the number of lamps turned on at one time.)

λ [nm]	1 PR714 1013	2 PR714 1057	3 PR714 1056	4 PR714 1055	4 SXR 1112	5 PR714 1044	6 PR714 1043	7 PR714 1042	8 PR714 1042	8 SXR 1100
382	0.1028	0.2144	0.3191	0.4273		0.5246	0.6433	0.7885	0.8629	
386	0.1129	0.2381	0.3560	0.4857		0.6001	0.7301	0.8559	0.9519	
390	0.1294	0.2661	0.3947	0.5280		0.6555	0.7998	0.9245	1.0645	
394	0.1450	0.3006	0.4327	0.5957		0.7213	0.8852	1.0440	1.1830	
398	0.1552	0.3233	0.4706	0.6431		0.7946	0.9543	1.1377	1.2809	
402	0.1664	0.3479	0.5112	0.6990		0.8723	1.0460	1.2439	1.3885	
406	0.1820	0.3780	0.5533	0.7567		0.9417	1.1387	1.3368	1.5253	
410	0.1975	0.4099	0.5982	0.8151		1.0019	1.2271	1.4494	1.6580	
411					0.8031					1.6066
414	0.2136	0.4444	0.6516	0.8890		1.0884	1.3215	1.5663	1.7738	
418	0.2311	0.4780	0.7044	0.9561		1.1717	1.4345	1.6879	1.9159	
422	0.2485	0.5165	0.7531	1.0301		1.2711	1.5359	1.8183	2.0686	
426	0.2679	0.5584	0.8068	1.1092		1.3649	1.6539	1.9512	2.2330	
430	0.2863	0.5933	0.8653	1.1840		1.4517	1.7686	2.0866	2.3784	
434	0.3053	0.6306	0.9242	1.2584		1.5499	1.8949	2.2169	2.5273	
438	0.3234	0.6725	0.9835	1.3394		1.6507	2.0148	2.3602	2.7015	
441					1.3470					2.6954
442	0.3450	0.7166	1.0460	1.4294		1.7643	2.1405	2.5117	2.8759	
446	0.3685	0.7628	1.1131	1.5168		1.8680	2.2717	2.6714	3.0509	
450	0.3907	0.8054	1.1735	1.6001		1.9766	2.3940	2.8217	3.2176	
454	0.4120	0.8513	1.2397	1.6907		2.0891	2.5288	2.9787	3.3813	
458	0.4315	0.8908	1.3059	1.7774		2.1997	2.6621	3.1306	3.5611	
462	0.4532	0.9369	1.3717	1.8690		2.3133	2.8025	3.3018	3.7533	
466	0.4774	0.9870	1.4444	1.9681		2.4320	2.9516	3.4702	3.9650	
470	0.5027	1.0364	1.5219	2.0738		2.5543	3.0894	3.6414	4.1586	
474	0.5308	1.0929	1.6020	2.1778		2.6818	3.2545	3.8353	4.3565	
478	0.5566	1.1472	1.6770	2.2790		2.8150	3.4056	4.0241	4.5806	
482	0.5810	1.1976	1.7498	2.3839		2.9453	3.5649	4.2094	4.7833	
486	0.6042	1.2477	1.8298	2.4872		3.0734	3.7194	4.3881	4.9867	
487					2.4582					4.9198
490	0.6332	1.3047	1.9138	2.6014		3.2205	3.8890	4.5876	5.2259	
494	0.6616	1.3628	1.9959	2.7166		3.3577	4.0585	4.7841	5.4500	
498	0.6876	1.4184	2.0794	2.8299		3.4899	4.2225	4.9789	5.6598	
502	0.7190	1.4771	2.1600	2.9382		3.6291	4.3952	5.1645	5.8824	
506	0.7460	1.5312	2.2435	3.0482		3.7676	4.5571	5.3627	6.1126	
510	0.7736	1.5902	2.3304	3.1631		3.9094	4.7360	5.5595	6.3475	
514	0.8039	1.6511	2.4193	3.2890		4.0633	4.9076	5.7833	6.5840	
518	0.8288	1.7046	2.5000	3.3991		4.1935	5.0705	5.9797	6.8164	
522	0.8574	1.7616	2.5880	3.5132		4.3425	5.2578	6.1979	7.0483	
526	0.8885	1.8272	2.6847	3.6454		4.5049	5.4497	6.4115	7.3047	
530	0.9203	1.8906	2.7764	3.7652		4.6571	5.6338	6.6266	7.5484	
534	0.9512	1.9513	2.8662	3.8864		4.8054	5.8134	6.8398	7.7962	
538	0.9853	2.0153	2.9622	4.0203		4.9682	6.0091	7.0642	8.0448	
542	1.0118	2.0721	3.0467	4.1380		5.1096	6.1783	7.2716	8.2831	
546	1.0387	2.1306	3.1335	4.2540		5.2631	6.3631	7.4918	8.5295	

Table 12. (cont.) GSFC sphere spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{ sr}^{-1}$], with intensity varied from 1–8 lamps, measured with the PR714 (small aperture) spectroradiometer and the SXR on 22 June 1993 (date and time are given in PDT). (The top line of the table header indicates the number of lamps turned on at one time.)

λ [nm]	1 PR714 1013	2 PR714 1057	3 PR714 1056	4 PR714 1055	4 SXR 1112	5 PR714 1044	6 PR714 1043	7 PR714 1042	8 PR714 1042	8 SXR 1100
547					4.2152					8.4261
550	1.0700	2.1933	3.2240	4.3765		5.4243	6.5496	7.7162	8.7801	
554	1.0997	2.2567	3.3197	4.5075		5.5834	6.7325	7.9341	9.0347	
558	1.1337	2.3229	3.4179	4.6369		5.7319	6.9290	8.1618	9.2807	
562	1.1687	2.3903	3.5102	4.7666		5.8955	7.1160	8.3754	9.5332	
566	1.1997	2.4546	3.6102	4.8971		6.0527	7.3176	8.5986	9.7933	
570	1.2300	2.5168	3.7041	5.0223		6.2066	7.4945	8.8188	10.0487	
574	1.2603	2.5838	3.7983	5.1432		6.3638	7.6873	9.0383	10.3007	
578	1.2892	2.6417	3.8870	5.2681		6.5236	7.8802	9.2684	10.5525	
582	1.3166	2.6983	3.9702	5.3824		6.6706	8.0614	9.4736	10.7973	
586	1.3481	2.7576	4.0595	5.5092		6.8231	8.2366	9.6973	11.0485	
590	1.3803	2.8263	4.1550	5.6436		6.9872	8.4321	9.9217	11.3010	
594	1.4125	2.8911	4.2602	5.7684		7.1434	8.6200	10.1499	11.5506	
598	1.4442	2.9544	4.3513	5.8931		7.3038	8.8160	10.3607	11.7901	
602	1.4771	3.0187	4.4441	6.0195		7.4528	9.0044	10.5817	12.0508	
606	1.5060	3.0759	4.5310	6.1329		7.5939	9.1669	10.7828	12.2718	
610	1.5400	3.1433	4.6300	6.2615		7.7602	9.3495	11.0012	12.5310	
614	1.5708	3.2035	4.7184	6.3857		7.9087	9.5353	11.2067	12.7612	
618	1.5932	3.2578	4.7939	6.4943		8.0405	9.7052	11.4106	12.9926	
622	1.6202	3.3138	4.8709	6.6032		8.1806	9.8712	11.6095	13.2186	
626	1.6499	3.3708	4.9598	6.7202		8.3336	10.0454	11.8139	13.4567	
630	1.6791	3.4308	5.0544	6.8444		8.4791	10.2319	12.0280	13.7030	
634	1.7097	3.4935	5.1411	6.9640		8.6336	10.4304	12.2422	13.9239	
638	1.7428	3.5523	5.2344	7.0777		8.7817	10.6101	12.4514	14.1833	
642	1.7705	3.6056	5.3213	7.1893		8.9160	10.7521	12.6518	14.4124	
646	1.7996	3.6592	5.4079	7.2994		9.0571	10.9356	12.8431	14.6308	
650	1.8304	3.7238	5.4843	7.4156		9.1961	11.0905	13.0288	14.8372	
654	1.8553	3.7829	5.5809	7.5276		9.3346	11.2602	13.2089	15.0471	
658	1.8828	3.8352	5.6463	7.6321		9.4633	11.4077	13.4066	15.2843	
661					7.5334					15.0438
662	1.9100	3.8880	5.7281	7.7384		9.6039	11.5818	13.5982	15.5032	
666	1.9307	3.9356	5.8033	7.8508		9.7379	11.7407	13.8024	15.7118	
670	1.9496	3.9844	5.8802	7.9464		9.8696	11.9044	13.9849	15.9233	
674	1.9754	4.0302	5.9653	8.0544		9.9945	12.0594	14.1615	16.1329	
678	2.0059	4.0867	6.0465	8.1713		10.1442	12.2130	14.3518	16.3606	
682	2.0347	4.1472	6.1260	8.2765		10.2633	12.3499	14.5463	16.5630	
686	2.0589	4.1894	6.1887	8.3769		10.3792	12.5166	14.7038	16.7518	
690	2.0859	4.2456	6.2708	8.4733		10.5194	12.6711	14.8925	16.9645	
694	2.1068	4.2918	6.3375	8.5545		10.6393	12.7932	15.0574	17.1512	
698	2.1330	4.3408	6.4082	8.6644		10.7612	12.9619	15.2130	17.3228	
702	2.1562	4.3898	6.4840	8.7572		10.8677	13.0961	15.3755	17.5226	
706	2.1803	4.4325	6.5502	8.8487		10.9838	13.2237	15.5355	17.7035	
710	2.2035	4.4775	6.6208	8.9477		11.1004	13.3702	15.7229	17.8891	
714	2.2278	4.5273	6.6927	9.0338		11.2117	13.4977	15.8771	18.0384	
718	2.2460	4.5659	6.7422	9.1058		11.3186	13.6281	16.0208	18.2574	

Table 12. (cont.) GSFC sphere spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{sr}^{-1}$], with intensity varied from 1–8 lamps, measured with the PR714 (small aperture) spectroradiometer and the SXR on 22 June 1993 (date and time are given in PDT). (The top line of the table header indicates the number of lamps turned on at one time.)

λ [nm]	1 PR714 1013	2 PR714 1057	3 PR714 1056	4 PR714 1055	4 SXR 1112	5 PR714 1044	6 PR714 1043	7 PR714 1042	8 PR714 1042	8 SXR 1100
722	2.2657	4.6054	6.8106	9.1972		11.4327	13.7776	16.1851	18.4257	
726	2.2915	4.6586	6.8932	9.3038		11.5560	13.9169	16.3502	18.5972	
730	2.3132	4.7034	6.9571	9.3946		11.6688	14.0395	16.4923	18.7912	
734	2.3300	4.7386	7.0083	9.4700		11.7673	14.1678	16.6397	18.9585	
738	2.3505	4.7820	7.0707	9.5538		11.8688	14.2892	16.7804	19.1198	
742	2.3702	4.8234	7.1307	9.6259		11.9512	14.3994	16.9175	19.2658	
746	2.3903	4.8660	7.1887	9.7022		12.0458	14.5106	17.0251	19.4104	
750	2.4077	4.8948	7.2389	9.7668		12.1278	14.6109	17.1537	19.5375	
754	2.4230	4.9217	7.2819	9.8314		12.1996	14.6993	17.2687	19.6488	
758	2.4341	4.9433	7.3174	9.8936		12.2707	14.7929	17.3751	19.7872	
762	2.4540	4.9812	7.3699	9.9605		12.3703	14.8905	17.5011	19.9410	
766	2.4752	5.0206	7.4325	10.0331		12.4611	14.9995	17.6282	20.0762	
770	2.4870	5.0493	7.4791	10.0966		12.5355	15.1048	17.7343	20.2133	
772					9.6859					19.3340
774	2.5030	5.0825	7.5332	10.1609		12.6257	15.2112	17.8470	20.3419	
778	2.5258	5.1284	7.5946	10.2588		12.7351	15.3225	18.0009	20.4873	
782	2.5410	5.1572	7.6331	10.2960		12.7963	15.4085	18.0917	20.6022	
786	2.5557	5.1902	7.6867	10.3703		12.8759	15.4941	18.1940	20.7406	
790	2.5749	5.2287	7.7360	10.4349		12.9668	15.6011	18.3175	20.8493	
794	2.5868	5.2498	7.7719	10.4831		13.0216	15.6732	18.4276	20.9661	
798	2.5915	5.2603	7.7972	10.5164		13.0708	15.7179	18.4475	21.0225	
802	2.6048	5.2888	7.8371	10.5735		13.1321	15.7934	18.5473	21.1264	
806	2.6217	5.3199	7.8734	10.6173		13.1953	15.8649	18.6160	21.2041	
810	2.6334	5.3369	7.8960	10.6514		13.2227	15.9160	18.6805	21.2925	
814	2.6393	5.3547	7.9271	10.6871		13.2829	15.9800	18.7481	21.3641	
818	2.6560	5.3837	7.9679	10.7350		13.3405	16.0470	18.8444	21.4599	
822	2.6611	5.3929	7.9915	10.7777		13.3914	16.0959	18.9014	21.5252	
826	2.6654	5.4023	8.0133	10.8027		13.4328	16.1536	18.9651	21.6053	
830	2.6780	5.4335	8.0490	10.8588		13.4956	16.2430	19.0508	21.7076	
834	2.6926	5.4550	8.0839	10.9059		13.5338	16.2830	19.1232	21.7612	
838	2.7020	5.4639	8.1009	10.9299		13.5811	16.3339	19.1781	21.8395	
842	2.7109	5.4900	8.1275	10.9555		13.6053	16.3874	19.2206	21.8907	
846	2.7183	5.5043	8.1540	10.9943		13.6378	16.4248	19.2835	21.9578	
850	2.7292	5.5256	8.1773	11.0160		13.6925	16.4621	19.3349	21.9907	
854	2.7357	5.5345	8.2029	11.0442		13.7147	16.5094	19.3558	22.0573	
858	2.7450	5.5513	8.2246	11.0777		13.7613	16.5385	19.3990	22.1034	
862	2.7450	5.5614	8.2371	11.0849		13.7827	16.5749	19.4616	22.1804	
866	2.7440	5.5551	8.2257	11.0934		13.7986	16.6087	19.4817	22.1869	
870	2.7490	5.5710	8.2616	11.1420		13.8545	16.6504	19.5403	22.2632	
874	2.7643	5.5986	8.2983	11.1721		13.9052	16.7008	19.5904	22.3130	
878	2.7749	5.6177	8.3206	11.2125		13.9268	16.7352	19.6479	22.3936	
882	2.7802	5.6248	8.3303	11.2184		13.9685	16.7705	19.6867	22.4057	
886	2.7750	5.6232	8.3301	11.2072		13.9522	16.7901	19.6900	22.4247	
890	2.7744	5.6208	8.3365	11.2107		13.9490	16.8006	19.7037	22.4523	
894	2.7762	5.6210	8.3328	11.2113		13.9425	16.7863	19.7119	22.4328	

Table 12. (cont.) GSFC sphere spectral radiance [$\mu\text{W cm}^{-2}\text{nm}^{-1}\text{sr}^{-1}$], with intensity varied from 1–8 lamps, measured with the PR714 (small aperture) spectroradiometer and the SXR on 22 June 1993 (date and time are given in PDT). (The top line of the table header indicates the number of lamps turned on at one time.)

λ [nm]	1 PR714 1013	2 PR714 1057	3 PR714 1056	4 PR714 1055	4 SXR 1112	5 PR714 1044	6 PR714 1043	7 PR714 1042	8 PR714 1042	8 SXR 1100
898	2.7762	5.6195	8.3336	11.2228		13.9521	16.8036	19.7060	22.4252	
902	2.7693	5.6169	8.3171	11.2135		13.9483	16.7542	19.6618	22.3762	
906	2.7664	5.5988	8.3044	11.1996		13.9184	16.7183	19.6197	22.3587	
910	2.7630	5.5929	8.2921	11.1675		13.8911	16.7159	19.6014	22.3351	
914	2.7583	5.5864	8.2840	11.1648		13.8674	16.6814	19.5763	22.3195	
918	2.7559	5.5787	8.2718	11.1453		13.8405	16.6673	19.5651	22.2602	
922	2.7584	5.5684	8.2690	11.1409		13.8476	16.6455	19.5244	22.2615	
926	2.7523	5.5667	8.2609	11.1191		13.8378	16.6481	19.5093	22.2585	
930	2.7482	5.5528	8.2365	11.1260		13.8384	16.6224	19.5191	22.2110	
934	2.7497	5.5489	8.2441	11.1164		13.8260	16.6282	19.5438	22.2225	
938	2.7486	5.5562	8.2396	11.1454		13.8568	16.6199	19.5382	22.2288	
942	2.7406	5.5434	8.2219	11.1033		13.8170	16.6136	19.4930	22.1963	
946	2.7432	5.5465	8.2316	11.0993		13.8404	16.6126	19.5095	22.2090	
950	2.7462	5.5518	8.2563	11.1160		13.8247	16.6376	19.5129	22.2112	
954	2.7441	5.5486	8.2364	11.0973		13.7986	16.5938	19.4724	22.2155	
958	2.7468	5.5467	8.2320	11.1038		13.8016	16.5932	19.4993	22.1867	
962	2.7458	5.5603	8.2520	11.1165		13.8019	16.6019	19.4955	22.1705	
966	2.7420	5.5434	8.2292	11.0826		13.7778	16.5667	19.4492	22.1444	
970	2.7366	5.5462	8.2129	11.0715		13.7820	16.5863	19.4741	22.1638	
974	2.7320	5.5315	8.2198	11.0568		13.7690	16.5644	19.4325	22.1447	
978	2.7380	5.5332	8.2295	11.0686		13.7784	16.5612	19.4482	22.0955	
982	2.7432	5.5473	8.2517	11.0988		13.7949	16.5853	19.4282	22.1977	
986	2.7437	5.5409	8.2311	11.0671		13.7919	16.5797	19.4513	22.1761	
990	2.7401	5.5430	8.2172	11.0693		13.7687	16.5621	19.4393	22.1073	
994	2.7462	5.5480	8.2102	11.0645		13.7833	16.5442	19.4625	22.0975	
998	2.7381	5.5361	8.2374	11.0658		13.7326	16.5358	19.3810	22.1002	
1002	2.7246	5.5236	8.2053	11.0158		13.7383	16.4923	19.3824	22.0421	
1006	2.7189	5.5039	8.1871	10.9973		13.7361	16.5064	19.3817	22.0576	
1010	2.7122	5.4871	8.1721	10.9929		13.7176	16.4737	19.3446	22.0171	
1014	2.7068	5.4902	8.1504	10.9638		13.6427	16.3836	19.3004	21.9069	
1018	2.7194	5.4841	8.1529	10.9991		13.6792	16.4316	19.2664	21.9260	
1022	2.7100	5.5007	8.1156	10.9455		13.6741	16.4338	19.2244	21.9220	
1026	2.7183	5.5014	8.1641	10.9575		13.6531	16.4105	19.2605	21.9355	
1030	2.7160	5.5122	8.1479	10.9544		13.6312	16.3390	19.2217	21.8985	
1034	2.7029	5.4833	8.1129	10.9254		13.5714	16.3725	19.1633	21.8197	
1038	2.6943	5.4351	8.0621	10.8639		13.5541	16.3166	19.0791	21.7486	
1042	2.6783	5.4248	8.0752	10.8393		13.4536	16.2745	19.0437	21.6890	
1046	2.6612	5.3903	8.0206	10.7928		13.4756	16.1379	18.9440	21.5446	
1050	2.6642	5.3748	8.0018	10.7578		13.4808	16.1522	18.9989	21.6497	
1054	2.6751	5.4035	8.0442	10.7757		13.4801	16.0905	18.9724	21.6245	
1058	2.6689	5.3473	7.9763	10.7471		13.3499	15.9527	18.7339	21.4837	
1062	2.6528	5.3605	7.9216	10.6915		13.2642	15.9740	18.6627	21.3830	
1066	2.6395	5.2864	7.9509	10.6040		13.1665	15.7914	18.6143	21.4684	
1070	2.6226	5.3298	7.8502	10.5110		13.0406	15.7458	18.5645	21.3626	

Table 13. GSFC sphere spectral radiance [$\mu\text{W cm}^{-2}\text{nm}^{-1}\text{sr}^{-1}$], with intensity varied from 9–16 lamps, measured with the PR714 (small aperture spectroradiometer on 22 June 1993 (date and time are given in PDT). The radiance was measured three times at 12 lamps and twice at 16 lamps.

λ [nm]	9 PR714 1041	10 PR714 1032	11 PR714 1031	12 PR714 1031	12 PR714 1028	12 SXR 1048	13 PR714 1017	14 PR714 1016	15 PR714 1015	16 PR714 1014	16 SXR 1030
382	0.9563	1.0800	1.2194	1.2816	1.3360		1.4714	1.5455	1.6927	1.7480	
386	1.0893	1.2529	1.3861	1.5134	1.5012		1.5820	1.7344	1.8738	2.0303	
390	1.2164	1.3403	1.5140	1.6462	1.6389		1.7877	1.9157	2.0707	2.2435	
394	1.3396	1.5081	1.6756	1.8020	1.7988		1.9986	2.0861	2.2838	2.4826	
398	1.4606	1.6651	1.8223	1.9504	1.9880		2.1516	2.3002	2.5014	2.6780	
402	1.5756	1.7850	1.9828	2.1454	2.1454		2.3124	2.5409	2.7387	2.9162	
406	1.7191	1.9256	2.1532	2.3154	2.3312		2.5250	2.7410	2.9601	3.1634	
410	1.8518	2.0910	2.3092	2.5040	2.4976		2.7199	2.9444	3.2027	3.4378	
411						2.4671					3.3309
414	1.9962	2.2592	2.5062	2.7157	2.7050		2.9253	3.1904	3.4406	3.6673	
418	2.1587	2.4352	2.6970	2.9292	2.9240		3.1699	3.4454	3.7199	3.9690	
422	2.3209	2.6250	2.8970	3.1618	3.1597		3.4079	3.7358	4.0099	4.2943	
426	2.4949	2.8068	3.1353	3.4046	3.3838		3.6780	3.9992	4.2819	4.6250	
430	2.6786	3.0195	3.3427	3.6115	3.5990		3.9305	4.2673	4.5759	4.9252	
434	2.8513	3.2005	3.5298	3.8339	3.8517		4.1946	4.5501	4.8836	5.2317	
438	3.0397	3.4079	3.7668	4.0936	4.1030		4.4598	4.8487	5.2034	5.5861	
441						4.1330					5.5749
442	3.2269	3.6364	4.0440	4.3819	4.3667		4.7329	5.1536	5.5419	5.9383	
446	3.4223	3.8543	4.2753	4.6365	4.6294		5.0221	5.4420	5.8822	6.3213	
450	3.6207	4.0852	4.5068	4.8874	4.8853		5.3130	5.7529	6.2123	6.6727	
454	3.8416	4.2998	4.7549	5.1585	5.1564		5.6095	6.0955	6.5228	7.0139	
458	4.0152	4.5125	4.9954	5.4320	5.4135		5.8861	6.3916	6.8756	7.3615	
462	4.2149	4.7448	5.2585	5.7028	5.7007		6.1838	6.7229	7.2467	7.7634	
466	4.4458	5.0093	5.5349	5.9948	6.0107		6.5134	7.0679	7.6264	8.1789	
470	4.6728	5.2635	5.8294	6.3039	6.3019		6.8390	7.4475	8.0194	8.6011	
474	4.9212	5.5191	6.1090	6.6161	6.6211		7.1646	7.8141	8.4090	9.0221	
478	5.1527	5.7877	6.4010	6.9545	6.9256		7.5420	8.1862	8.8212	9.4417	
482	5.3842	6.0453	6.6950	7.2647	7.2409		7.8750	8.5631	9.2044	9.8769	
486	5.6245	6.3014	6.9865	7.5769	7.5728		8.2219	8.9462	9.6118	10.3134	
487						7.5369					10.2018
490	5.8802	6.6081	7.2927	7.9169	7.9138		8.5903	9.3534	10.0521	10.7820	
494	6.1240	6.8903	7.6090	8.2501	8.2541		8.9658	9.7610	10.4866	11.2321	
498	6.3645	7.1458	7.9162	8.5533	8.5861		9.3217	10.1487	10.8942	11.6595	
502	6.6195	7.4309	8.2262	8.9190	8.9311		9.6912	10.5237	11.3170	12.1103	
506	6.8676	7.7230	8.5215	9.2531	9.2511		10.0395	10.9081	11.7402	12.5824	
510	7.1345	7.9997	8.8599	9.6062	9.6123		10.4216	11.3468	12.1805	13.0549	
514	7.4019	8.3153	9.1931	9.9755	9.9826		10.8279	11.7717	12.6343	13.5476	
518	7.6571	8.6126	9.5087	10.3202	10.3202		11.1962	12.1628	13.0790	14.0254	
522	7.9176	8.9066	9.8488	10.6692	10.6892		11.5974	12.5955	13.5636	14.5317	
526	8.2138	9.2202	10.1829	11.0662	11.0563		12.0289	13.0512	14.0437	15.0362	
530	8.4903	9.5140	10.5278	11.4177	11.4277		12.4075	13.4772	14.4970	15.5368	
534	8.7556	9.8296	10.8711	11.7829	11.7728		12.7758	13.9106	14.9642	16.0078	
538	9.0417	10.1500	11.2153	12.1755	12.1652		13.2173	14.3613	15.4338	16.5165	
542	9.3068	10.4625	11.5466	12.5284	12.5387		13.6125	14.7785	15.8932	17.0285	
546	9.6009	10.7449	11.8695	12.9021	12.9021		14.0062	15.2228	16.3678	17.5435	
547						12.8564					17.2924

Table 13. (cont.) GSFC sphere spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{ sr}^{-1}$], with intensity varied from 9–16 lamps, measured with the PR714 (small aperture spectroradiometer on 22 June 1993 (date and time are given in PDT). The radiance was measured three times at 12 lamps and twice at 16 lamps.

λ [nm]	9 PR714 1041	10 PR714 1032	11 PR714 1031	12 PR714 1031	12 PR714 1028	12 SXR 1048	13 PR714 1017	14 PR714 1016	15 PR714 1015	16 PR714 1014	16 SXR 1030
550	9.8652	11.0519	12.2296	13.2764	13.2865		14.4339	15.6820	16.8597	18.0474	
554	10.1552	11.3924	12.5702	13.6491	13.6590		14.8368	16.1136	17.3410	18.5485	
558	10.4154	11.7037	12.9226	14.0226	14.0226		15.2316	16.5497	17.8082	19.0668	
562	10.7009	12.0360	13.2915	14.4074	14.4074		15.6529	16.9979	18.2832	19.5885	
566	11.0140	12.3482	13.6422	14.8058	14.7957		16.0897	17.4640	18.7780	20.1021	
570	11.2848	12.6447	13.9639	15.1614	15.1614		16.4705	17.8811	19.2308	20.6211	
574	11.5641	12.9497	14.3150	15.5580	15.5580		16.8927	18.3599	19.7251	21.1312	
578	11.8499	13.2902	14.6795	15.9565	15.9462		17.3253	18.8065	20.2469	21.6260	
582	12.1292	13.5933	15.0065	16.3079	16.3079		17.7008	19.2563	20.7102	22.1336	
586	12.4057	13.9036	15.3512	16.6682	16.7084		18.1259	19.6942	21.1720	22.6499	
590	12.6913	14.2405	15.7202	17.0707	17.0807		18.5206	20.1492	21.6587	23.1880	
594	12.9809	14.5492	16.0387	17.4492	17.4295		18.9090	20.5760	22.1148	23.6634	
598	13.2491	14.8461	16.3740	17.8232	17.8133		19.3314	21.0467	22.5944	24.1815	
602	13.5299	15.1678	16.7560	18.1755	18.1854		19.7538	21.4811	23.0693	24.6973	
606	13.7708	15.4297	17.0586	18.5076	18.4976		20.1165	21.8654	23.5043	25.1532	
610	14.0509	15.7519	17.3925	18.8922	18.8821		20.4925	22.2841	23.9751	25.6459	
614	14.3259	16.0836	17.7194	19.2536	19.2536		20.9097	22.7080	24.4353	26.1117	
618	14.5746	16.3199	18.0345	19.6063	19.5859		21.2597	23.1275	24.8319	26.6180	
622	14.8480	16.6200	18.3512	19.9399	19.9501		21.6508	23.5450	25.2966	27.0787	
626	15.1198	16.9350	18.6792	20.3017	20.3321		22.0459	23.9726	25.7777	27.5523	
630	15.3781	17.2347	19.0208	20.6656	20.6958		22.4415	24.3991	26.2255	28.0519	
634	15.6456	17.5275	19.3393	21.0310	21.0410		22.8228	24.8248	26.6566	28.5385	
638	15.9550	17.8361	19.6874	21.4292	21.3994		23.2805	25.2114	27.1523	29.0235	
642	16.1530	18.1025	19.9625	21.7329	21.7230		23.5631	25.5921	27.5516	29.5011	
646	16.3885	18.3858	20.2933	22.0510	22.0610		23.9585	25.9958	27.9533	29.9207	
650	16.6856	18.6639	20.6123	22.3908	22.4107		24.2691	26.3573	28.3756	30.3039	
654	16.9054	18.9144	20.8932	22.7013	22.6912		24.6299	26.7995	28.7784	30.7773	
658	17.1519	19.1912	21.1799	22.9870	23.0274		24.9758	27.1765	29.1956	31.2248	
661						22.8781					30.7001
662	17.3980	19.4955	21.5221	23.3662	23.3358		25.3827	27.5511	29.6384	31.6751	
666	17.6516	19.7946	21.8157	23.6845	23.6845		25.7157	27.9704	30.0627	32.1142	
670	17.8719	19.9929	22.0531	24.0017	24.0321		26.0314	28.3149	30.4461	32.5266	
674	18.1243	20.2667	22.3386	24.2898	24.3301		26.4221	28.6851	30.8476	32.9497	
678	18.3595	20.5882	22.6970	24.6559	24.6659		26.7847	29.0933	31.2621	33.4509	
682	18.5597	20.7861	22.9326	24.9094	24.9094		27.0758	29.3921	31.6184	33.8448	
686	18.7998	21.0367	23.2139	25.2222	25.2421		27.3994	29.7954	31.9925	34.2493	
690	19.0265	21.2878	23.4893	25.5613	25.5414		27.7230	30.1337	32.3850	34.6363	
694	19.2249	21.4991	23.7431	25.8269	25.8069		28.0009	30.4553	32.7194	34.9635	
698	19.4024	21.7141	23.9754	26.1054	26.0751		28.3162	30.7894	33.0810	35.3422	
702	19.6391	22.0100	24.2690	26.3958	26.3856		28.6344	31.1173	33.4679	35.7574	
706	19.8509	22.2347	24.5157	26.6323	26.6528		28.9544	31.4512	33.7938	36.1365	
710	20.0553	22.4391	24.7712	26.9166	26.9270		29.2383	31.8086	34.1407	36.5038	
714	20.2621	22.6623	25.0107	27.2031	27.1823		29.5203	32.0556	34.4559	36.8666	
718	20.4629	22.8868	25.2795	27.4746	27.4642		29.8153	32.4265	34.8088	37.2223	
722	20.6664	23.1155	25.5126	27.7428	27.7324		30.1086	32.7244	35.1423	37.5602	
726	20.8856	23.3397	25.7731	28.0304	28.0097		30.3913	33.0318	35.5066	37.9607	

Table 13. (cont.) GSFC sphere spectral radiance [$\mu\text{W cm}^{-2}\text{nm}^{-1}\text{sr}^{-1}$], with intensity varied from 9–16 lamps, measured with the PR714 (small aperture spectroradiometer on 22 June 1993 (date and time are given in PDT). The radiance was measured three times at 12 lamps and twice at 16 lamps.

λ [nm]	9 PR714 1041	10 PR714 1032	11 PR714 1031	12 PR714 1031	12 PR714 1028	12 SXR 1048	13 PR714 1017	14 PR714 1016	15 PR714 1015	16 PR714 1014	16 SXR 1030
730	21.0695	23.5737	25.9854	28.2638	28.2945		30.6755	33.3541	35.8274	38.3008	
734	21.2568	23.7900	26.2211	28.5297	28.5194		30.9608	33.6472	36.1600	38.6422	
738	21.4490	23.9909	26.4618	28.7911	28.7708		31.2621	33.9356	36.4673	38.9586	
742	21.6141	24.1722	26.6703	29.0186	28.9886		31.4768	34.1848	36.7429	39.2610	
746	21.7460	24.3400	26.8446	29.2001	29.2001		31.6550	34.4180	37.0120	39.5265	
750	21.8816	24.4939	27.0267	29.3609	29.3808		31.8937	34.6550	37.2574	39.7604	
754	22.0489	24.6681	27.1977	29.5778	29.5579		32.1273	34.9058	37.5051	40.0446	
758	22.1793	24.8216	27.3738	29.7659	29.7759		32.3481	35.1205	37.7328	40.3251	
762	22.3508	25.0116	27.5620	30.0119	30.0019		32.5322	35.3737	38.0145	40.6452	
766	22.4942	25.1931	27.7516	30.2197	30.2297		32.7882	35.6075	38.2863	40.8749	
770	22.6622	25.3319	27.9614	30.4003	30.4003		33.0198	35.8701	38.5598	41.1492	
772						29.3347					39.3107
774	22.8067	25.4928	28.1588	30.6034	30.5934		33.2090	36.1064	38.7724	41.4384	
778	22.9737	25.6925	28.3406	30.8067	30.8067		33.4649	36.3455	39.0643	41.7023	
782	23.1229	25.8468	28.4996	30.9999	30.9796		33.6425	36.5392	39.2631	41.9362	
786	23.2462	25.9768	28.6563	31.1518	31.1518		33.8108	36.7766	39.4766	42.2072	
790	23.4119	26.1385	28.8344	31.3355	31.3765		34.0108	36.9732	39.7100	42.4469	
794	23.4944	26.2693	28.9723	31.5211	31.5417		34.2138	37.1532	39.9384	42.6208	
798	23.5769	26.3683	29.0566	31.6007	31.6419		34.3302	37.2658	40.0571	42.7557	
802	23.6645	26.4902	29.2030	31.7410	31.7513		34.4640	37.4542	40.2286	42.9413	
806	23.7617	26.5943	29.3149	31.8724	31.8826		34.5624	37.5479	40.3806	43.1215	
810	23.8334	26.6487	29.3928	31.9744	31.9540		34.6779	37.6761	40.5015	43.2660	
814	23.9396	26.7584	29.5062	32.0918	32.1020		34.8194	37.8917	40.6497	43.4482	
818	24.0755	26.8729	29.6602	32.2455	32.2455		35.0226	38.0422	40.8194	43.6268	
822	24.1389	26.9746	29.7598	32.3735	32.3534		35.1386	38.1862	41.0018	43.7870	
826	24.1951	27.0671	29.8383	32.4785	32.4785		35.2497	38.3131	41.1650	43.9462	
830	24.3343	27.2125	30.0103	32.6168	32.6671		35.4246	38.4940	41.3220	44.1298	
834	24.4195	27.3102	30.0695	32.7076	32.7581		35.5073	38.5900	41.4302	44.3209	
838	24.4805	27.3654	30.1588	32.8100	32.8405		35.6441	38.7321	41.6068	44.4205	
842	24.5404	27.4143	30.1965	32.8870	32.8768		35.7100	38.7877	41.6718	44.4948	
846	24.6014	27.4806	30.3188	32.9418	32.9623		35.7903	38.8950	41.7947	44.6329	
850	24.6569	27.5608	30.3716	33.0378	33.0378		35.8797	38.9695	41.8527	44.6739	
854	24.7175	27.6260	30.4311	33.1429	33.1222		35.9790	39.0428	41.9721	44.7564	
858	24.7974	27.7099	30.5079	33.2123	33.1915		36.0207	39.1516	42.0537	44.8725	
862	24.7941	27.7438	30.5256	33.2233	33.2338		36.0680	39.1962	42.0934	44.9486	
866	24.8606	27.7756	30.6171	33.2803	33.3223		36.1638	39.2989	42.1614	45.0868	
870	24.9548	27.8759	30.7344	33.4365	33.4365		36.2846	39.4248	42.3772	45.2045	
874	25.0252	27.9356	30.7938	33.4955	33.4955		36.3433	39.4937	42.4458	45.3040	
878	25.0871	27.9894	30.8812	33.5852	33.5956		36.4770	39.5881	42.5635	45.4031	
882	25.1454	28.0720	30.9155	33.6552	33.6656		36.5091	39.7158	42.6424	45.5274	
886	25.1594	28.1005	30.9797	33.6732	33.6732		36.5627	39.7412	42.7236	45.5408	
890	25.1495	28.0937	30.9453	33.6733	33.7042		36.5661	39.7265	42.7016	45.5635	
894	25.1436	28.0897	30.9743	33.6544	33.6953		36.5698	39.7306	42.6562	45.5613	
898	25.1341	28.1078	30.9695	33.7090	33.7090		36.5606	39.7685	42.7117	45.5530	
902	25.0805	27.9983	30.8957	33.5898	33.5796		36.4567	39.6388	42.5769	45.4845	
906	25.0470	27.9788	30.8092	33.5381	33.5482		36.4191	39.6045	42.5465	45.4478	

Table 13. (cont.) GSFC sphere spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{ sr}^{-1}$], with intensity varied from 9–16 lamps, measured with the PR714 (small aperture spectroradiometer on 22 June 1993 (date and time are given in PDT). The radiance was measured three times at 12 lamps and twice at 16 lamps.

λ [nm]	9 PR714 1041	10 PR714 1032	11 PR714 1031	12 PR714 1031	12 PR714 1028	12 SXR 1048	13 PR714 1017	14 PR714 1016	15 PR714 1015	16 PR714 1014	16 SXR 1030
910	25.0080	27.9239	30.7791	33.4824	33.5128		36.3679	39.5268	42.4630	45.3283	
914	24.9917	27.8765	30.7209	33.4033	33.4437		36.3185	39.5576	42.4120	45.2361	
918	24.9554	27.8531	30.7104	33.4562	33.4258		36.2527	39.4544	42.4130	45.1790	
922	24.9378	27.8573	30.6856	33.3720	33.4328		36.2713	39.4138	42.3840	45.1617	
926	24.9263	27.8690	30.7200	33.4183	33.3979		36.2897	39.4361	42.3584	45.1687	
930	24.9132	27.8099	30.6860	33.3677	33.3370		36.2337	39.3964	42.3238	45.1897	
934	24.9424	27.8374	30.6705	33.3801	33.3595		36.2545	39.4174	42.3433	45.1765	
938	24.9091	27.7963	30.6422	33.3328	33.3225		36.2201	39.3557	42.3879	45.2130	
942	24.8893	27.6755	30.5860	33.2997	33.2997		36.1998	39.2864	42.2072	45.1177	
946	24.9086	27.7431	30.6088	33.3187	33.3187		36.2052	39.3512	42.2584	45.0722	
950	24.8886	27.7744	30.6602	33.3376	33.3584		36.1713	39.3905	42.2762	45.0370	
954	24.8542	27.7537	30.5697	33.2919	33.3023		36.2018	39.2995	42.2094	45.0463	
958	24.8325	27.7699	30.6031	33.3009	33.3530		36.1862	39.3111	42.2173	45.0088	
962	24.8352	27.8225	30.5704	33.2350	33.3599		36.1702	39.2824	42.2177	44.9760	
966	24.7980	27.7013	30.5214	33.2166	33.1958		36.0887	39.1898	42.1035	44.9548	
970	24.8326	27.6578	30.5560	33.2665	33.1205		36.1438	39.1463	42.1695	44.9322	
974	24.7842	27.6939	30.4893	33.2327	33.1080		36.0176	39.1767	42.0656	44.8817	
978	24.8262	27.6715	30.5376	33.2162	33.2370		36.0198	39.2924	42.1690	44.9101	
982	24.8203	27.7156	30.5271	33.2336	33.2965		36.0135	39.2761	42.1190	44.9933	
986	24.8381	27.6992	30.5079	33.3061	33.2746		36.0728	39.2483	42.1723	44.8343	
990	24.8066	27.6733	30.5296	33.2394	33.1347		36.0433	39.1821	42.1116	44.8004	
994	24.7533	27.5772	30.4850	33.1724	33.0989		35.9333	39.0931	42.0324	44.7933	
998	24.7774	27.6016	30.4573	33.1555	33.1240		35.8852	39.0349	42.0796	44.7673	
1002	24.7123	27.5709	30.4087	33.1102	33.0265		35.8852	39.0161	41.9480	44.5973	
1006	24.7019	27.5772	30.4104	33.0863	32.9919		35.8986	39.0257	41.9009	44.6922	
1010	24.6688	27.5188	30.3479	33.0309	33.1040		35.7974	38.9710	41.9254	44.7546	
1014	24.6375	27.5336	30.3263	33.0258	33.0362		35.7254	38.9111	41.8279	44.6102	
1018	24.6165	27.4616	30.2449	32.9456	32.9663		35.8217	38.8111	41.8006	44.5117	
1022	24.5990	27.4413	30.2836	32.8882	32.8469		35.7615	38.8416	41.7046	44.4228	
1026	24.4665	27.3165	30.2488	32.9650	32.9238		35.7018	38.7370	41.5972	44.5295	
1030	24.5548	27.3757	30.2482	32.8632	32.8220		35.6533	38.6802	41.6247	44.7134	
1034	24.5381	27.3289	30.0990	32.6831	32.8071		35.4738	38.6264	41.5515	44.2286	
1038	24.5318	27.2219	29.9741	32.6125	32.5711		35.4371	38.6446	41.2312	44.2007	
1042	24.3962	26.9071	29.9140	32.2700	32.5490		35.4732	38.2528	41.1047	44.2046	
1046	24.2685	26.9821	29.5416	32.1730	32.5327		35.3594	38.1861	41.0745	43.9115	
1050	24.0633	26.8172	29.5402	32.4178	32.3456		35.2440	37.8638	40.9890	43.3201	
1054	23.9948	26.8558	29.6855	32.4107	32.3376		34.9585	38.0492	41.0668	43.4371	
1058	23.8451	26.8257	29.6489	31.8529	32.1468		34.4767	38.1291	40.6479	43.5761	
1062	23.9557	26.9502	29.5967	31.9480	32.1694		34.5945	37.5257	40.6151	43.4092	
1066	23.9163	26.6975	29.6245	32.2703	31.8953		34.3640	37.5202	40.3327	43.3014	
1070	23.6445	26.4116	28.8793	31.6671	31.7497		34.4549	37.3975	40.0407	43.0040	

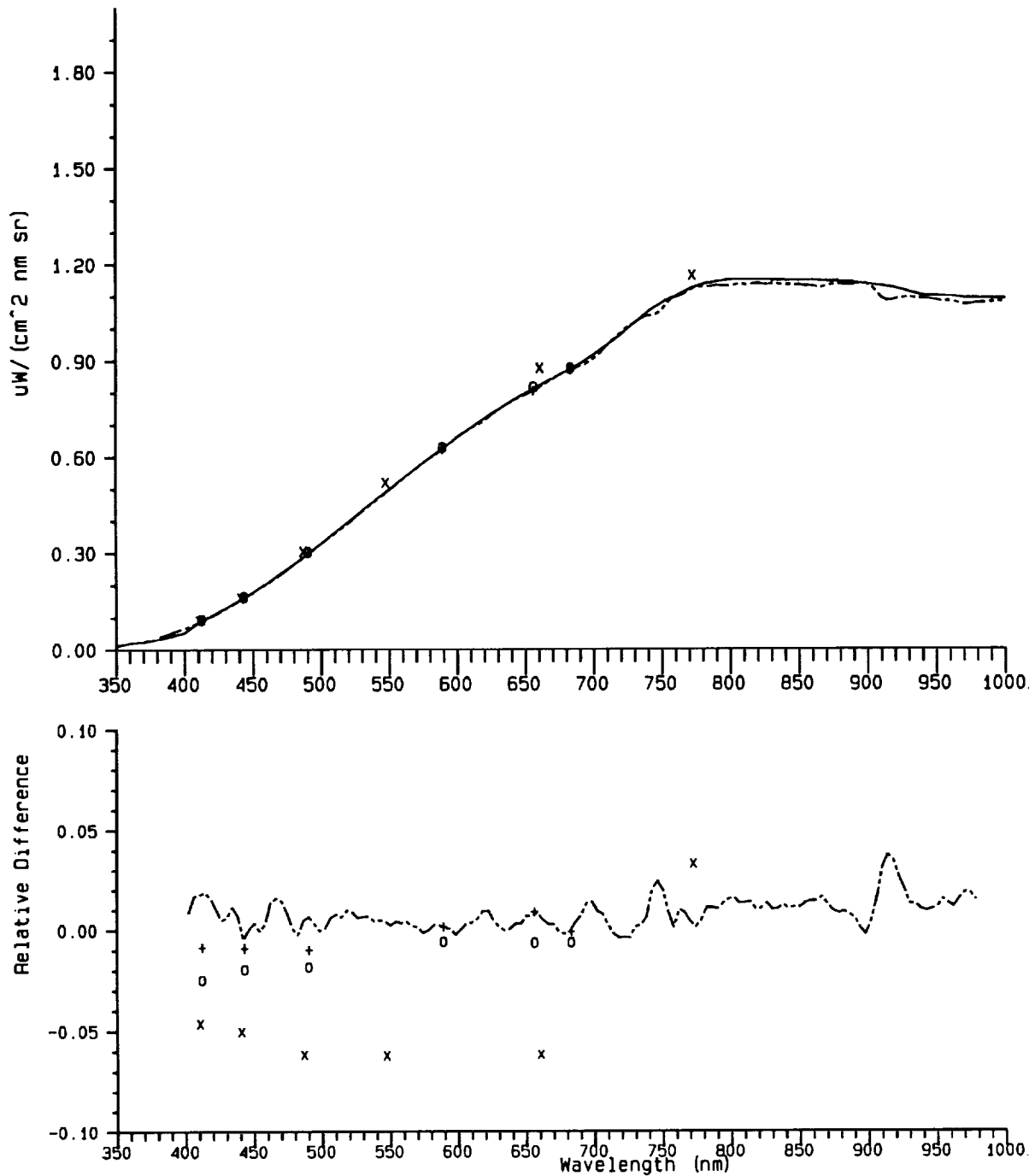


Fig. 22. Spectral radiance of the BSI sphere measured with the 746/ISIC (solid line) on 17 June 1993, the PR714 (dashed line) on 24 June 1993, the BSIXR on 17 June 1993 (o) and 23 June 1993 (+), and the SXR on 23 June 1993 (x). The top panel illustrates spectral radiance ($\mu W cm^{-2} nm^{-1} sr^{-1}$) of the sphere, and the bottom panel illustrates the departures of the PR714 radiances relative to the F269 calibrated scale. (Note that below 400 nm, the PR714 reads approximately 35% above $[-0.35$ relative difference] the 746/ISIC and is not graphed in the bottom panel.)

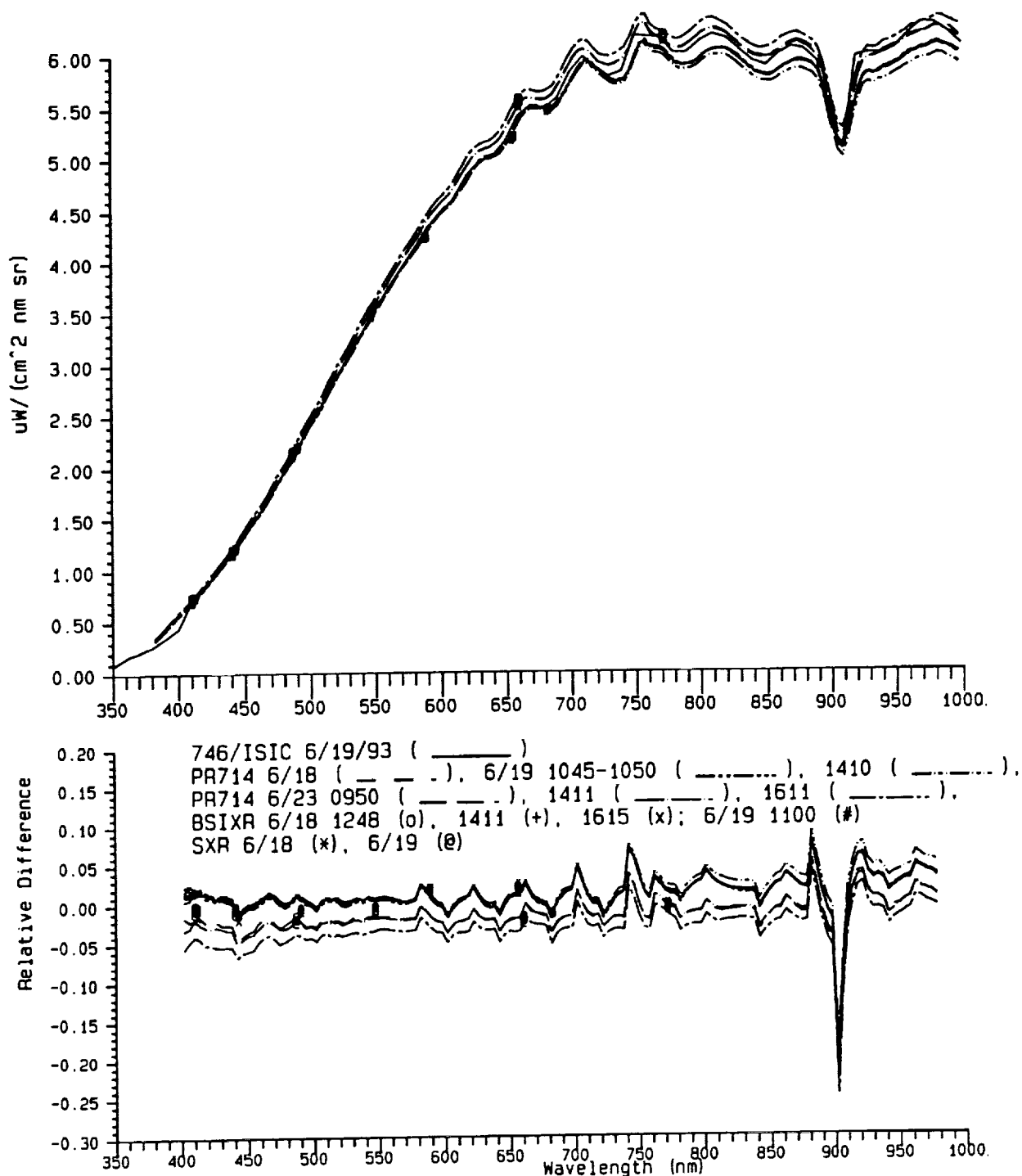


Fig. 23. Spectral radiance of the CHORS sphere (four 250 W lamps: apertures 1.25, 1.25, 1.25, and 1.25) measured with the 746/ISIC (19 June), the PR714 (18, 19, and 23 June 1993), the BSIXR (18 and 19 June 1993) [see key above; times in PDT], and the SXR (18 and 19 June 1993). The top panel illustrates spectral radiance ($\mu\text{W cm}^{-2} \text{nm}^{-1} \text{sr}^{-1}$) of the sphere, and the bottom panel illustrates the departures of the PR714 radiances relative to the F269 calibrated scale of 19 June.

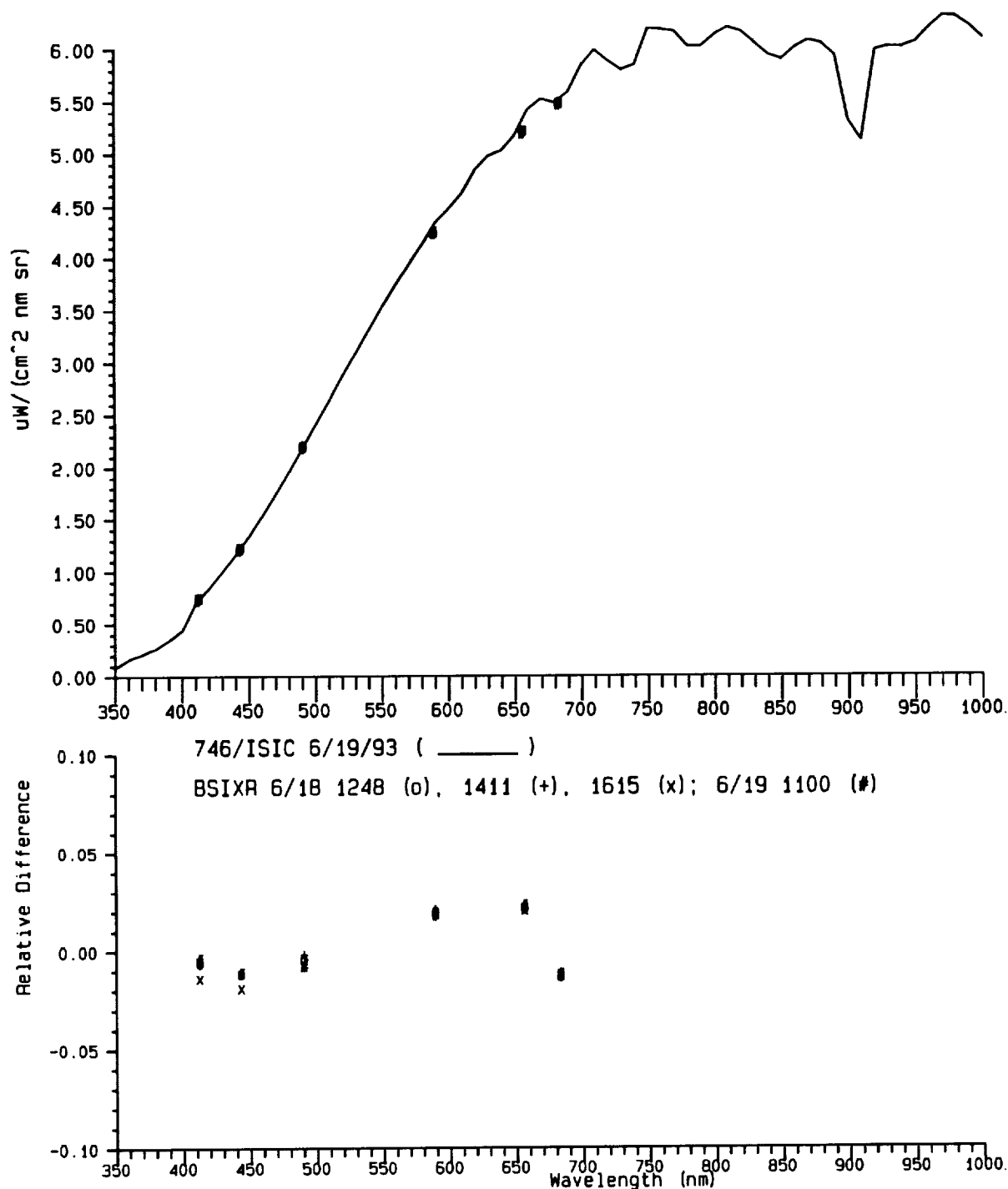


Fig. 24. Spectral radiance of the CHORS sphere (four 250 W lamps: apertures 1.25, 1.25, 1.25, and 1.25) measured with the 746/ISIC (19 June), and the BSIXR (18 and 19 June 1993) [see key above; times in PDT]. The top panel illustrates spectral radiance ($\mu W cm^{-2} nm^{-1} sr^{-1}$) of the sphere, and the bottom panel illustrates the departures of the PR714 radiances relative to the F269 calibrated scale of 19 June.

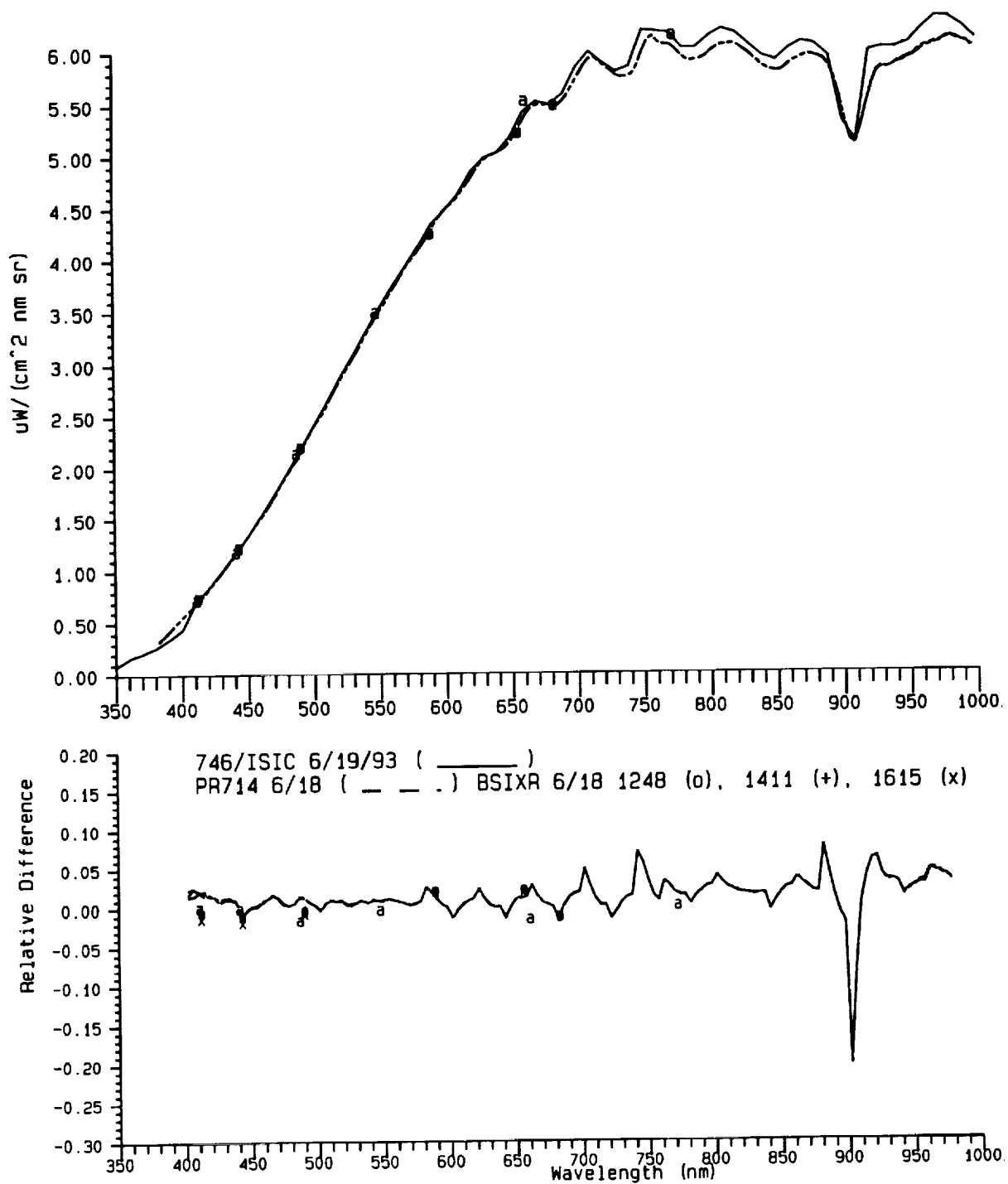


Fig. 25. Spectral radiance of the CHORS sphere (four 250 W lamps: apertures 1.25, 1.25, 1.25, and 1.25) measured with the 746/ISIC (19 June), the PR714 (18 June), and the BSIXR (18 June) [see key above; times in PDT]; and the SXR on 18 June (a). The top panel illustrates spectral radiance ($\mu W cm^{-2} nm^{-1} sr^{-1}$) of the sphere, and the bottom panel illustrates the departures of the PR714 and BSIXR radiances relative to the F269 calibrated scale of 19 June.

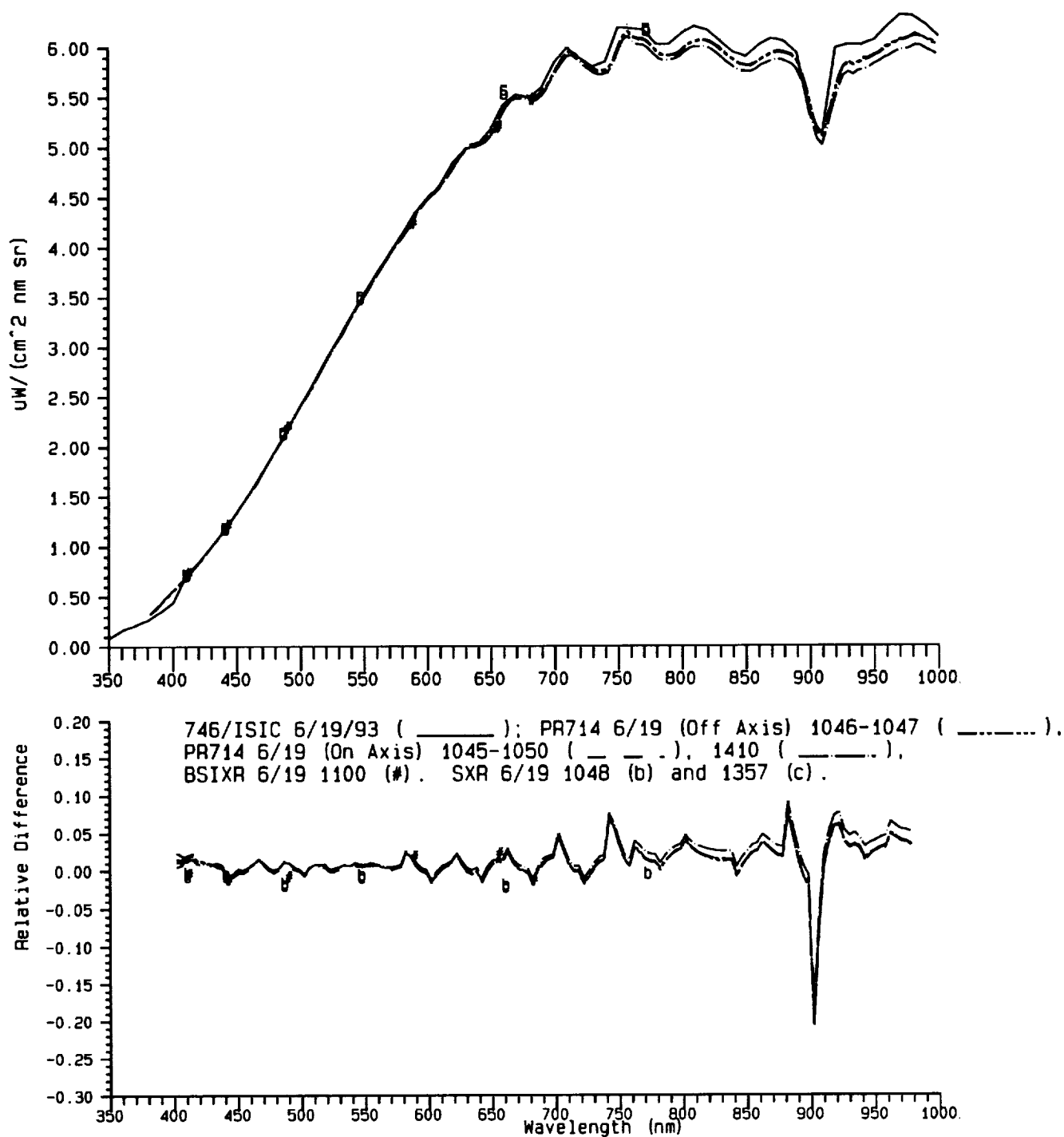


Fig. 26. Spectral radiance of the CHORS sphere (four 250 W lamps: apertures 1.25, 1.25, 1.25, and 1.25) measured with the 746/ISIC, the PR714, the SXR, and the BSIXR (all on 19 June) [see key above; times in PDT]. The top panel illustrates spectral radiance ($\mu\text{W cm}^{-2} \text{ nm}^{-1} \text{ sr}^{-1}$) of the sphere, and the bottom panel illustrates the departures of the PR714 and BSIXR radiances relative to the F269 calibrated scale of 19 June.

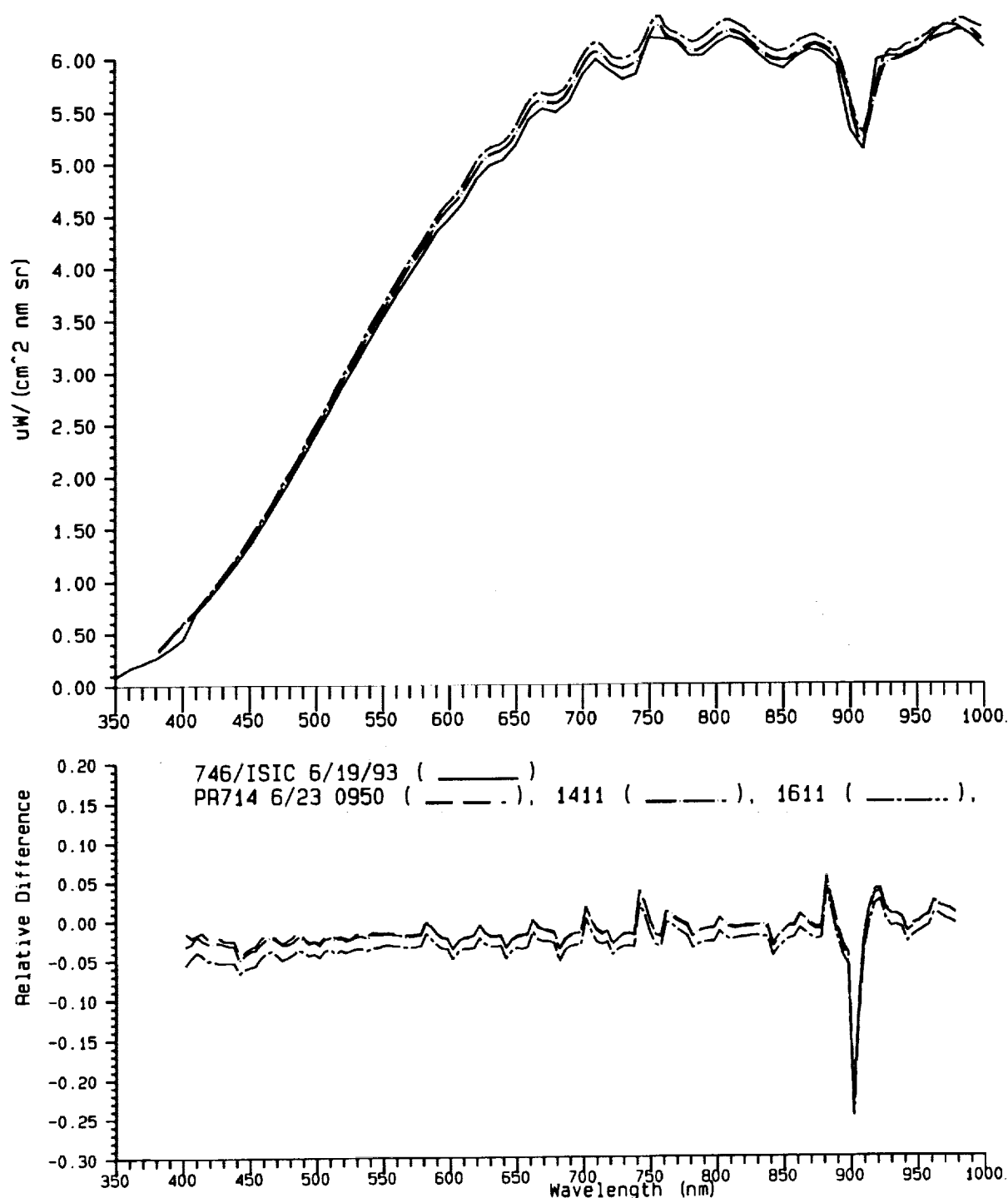


Fig. 27. Spectral radiance of the CHORS sphere (four 250 W lamps: apertures 1.25, 1.25, 1.25, and 1.25) measured with the 746/ISIC (19 June), and the PR714 (23 June) [see key above; times in PDT]. The top panel illustrates spectral radiance ($\mu W cm^{-2} nm^{-1} sr^{-1}$) of the sphere, and the bottom panel illustrates the departures of the PR714 radiances relative to the F269 calibrated scale of 19 June.

Table 14. BSI sphere (open aperture) spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{sr}^{-1}$] measured with the 746/ISIC, the PR714 (large aperture), and the BSIXR on 17, 23, and 24 June 1993; and the SXR on 23 June 1993 (date and time given in PDT).

λ [nm]	746 17 June 1702	BSIXR 17 June 1715	BSIXR 23 June 1214	SXR 23 June 1230	PR714 24 June 1812	λ [nm]	746 17 June 1702	BSIXR 17 June 1715	BSIXR 23 June 1214	SXR 23 June 1230	PR714 24 June 1812
350	0.0115					510	0.3639				0.3611
360	0.0216					514					0.3752
370	0.0248					518					0.3873
380	0.0321					520	0.3980				
382					0.0396	522					0.4019
386					0.0466	526					0.4166
390	0.0416				0.0513	530	0.4326				0.4297
394					0.0591	534					0.4432
398					0.0647	538					0.4576
400	0.0536					540	0.4664				
402					0.0706	542					0.4699
406					0.0780	546					0.4836
410	0.0874				0.0859	547				0.5195	
411				0.0915		550	0.4994				0.4983
412		0.0937	0.0922			554					0.5110
414					0.0937	558					0.5250
418					0.1019	560	0.5336				
420	0.1076					562					0.5386
422					0.1102	566					0.5522
426					0.1203	570	0.5660				0.5653
430	0.1304				0.1296	574					0.5796
434					0.1382	578					0.5915
438					0.1483	580	0.5977				
440	0.1541					582					0.6012
441				0.1622		586					0.6141
442					0.1593	589		0.6289	0.6242		
443		0.1643	0.1626			590	0.6284				0.6278
446					0.1691	594					0.6408
450	0.1797				0.1791	598					0.6556
454					0.1904	600	0.6605				
458					0.2003	602					0.6684
460	0.2062					606					0.6777
462					0.2105	610	0.6913				0.6889
466					0.2216	614					0.6989
470	0.2368				0.2333	618					0.7074
474					0.2463	620	0.7198				
478					0.2598	622					0.7195
480	0.2659					626					0.7334
482					0.2716	630	0.7471				0.7461
486					0.2827	634					0.7577
487				0.3041		638					0.7675
490	0.2971	0.3026	0.3001		0.2952	640	0.7730				
494					0.3092	642					0.7768
498					0.3235	646					0.7861
500	0.3299					650	0.7978				0.7923
502					0.3364	654					0.8015
506					0.3482	656		0.8171	0.8046		

Table 14. (cont.) BSI sphere (open aperture) spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{sr}^{-1}$] measured with the 746/ISIC, the PR714 (large aperture), and the BSIXR on 17, 23, and 24 June 1993; and the SXR on 23 June 1993 (date and time given in PDT).

λ [nm]	746 17 June 1702	BSIXR 17 June 1715	BSIXR 23 June 1214	SXR 23 June 1230	PR714 24 June 1812	λ [nm]	746 17 June 1702	BSIXR 17 June 1715	BSIXR 23 June 1214	SXR 23 June 1230	PR714 24 June 1812
658					0.8095	802					1.1325
660	0.8210					806					1.1353
661				0.8761		810	1.1498				1.1344
662					0.8214	814					1.1334
666					0.8322	818					1.1373
670	0.8434				0.8410	820	1.1486				
674					0.8535	822					1.1363
678					0.8629	826					1.1330
680	0.8656					830	1.1479				1.1363
682					0.8678	834					1.1356
683		0.8753	0.8706			838					1.1331
686					0.8748	840	1.1470				
690	0.8894				0.8833	842					1.1332
694					0.8890	846					1.1327
698					0.8993	850	1.1460				1.1332
700	0.9176					854					1.1310
702					0.9131	858					1.1303
706					0.9275	860	1.1468				
710	0.9480				0.9459	862					1.1282
714					0.9632	866					1.1256
718					0.9783	870	1.1443				1.1297
720	0.9810					874					1.1333
722					0.9931	878					1.1347
726					1.0070	880	1.1442				
730	1.0166				1.0151	882					1.1343
734					1.0280	886					1.1341
738					1.0374	890	1.1404				1.1337
740	1.0505					894					1.1376
742					1.0392	898					1.1389
746					1.0430	900	1.1350				
750	1.0775				1.0563	902					1.1298
754					1.0766	906					1.1146
758					1.0936	910	1.1299				1.0946
760	1.0988					914					1.0852
762					1.0976	918					1.0857
766					1.1052	920	1.1236				
770	1.1205				1.1159	922					1.0908
772				1.1638		926					1.0931
774					1.1247	930	1.1114				1.0971
778					1.1270	934					1.0930
780	1.1351					938					1.0910
782					1.1266	940	1.1002				
786					1.1288	942					1.0906
790	1.1432				1.1314	946					1.0888
794					1.1304	950	1.0993				1.0870
798					1.1299	954					1.0816
800	1.1485					958					1.0833

Table 14. (cont.) BSI sphere (open aperture) spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{ sr}^{-1}$] measured with the 746/ISIC, the PR714 (large aperture), and the BSIXR on 17, 23, and 24 June 1993; and the SXR on 23 June 1993 (date and time given in PDT).

λ [nm]	746 17 June 1702	BSIXR 17 June 1715	BSIXR 23 June 1214	SXR 23 June 1230	PR714 24 June 1812	λ [nm]	746 17 June 1702	BSIXR 17 June 1715	BSIXR 23 June 1214	SXR 23 June 1230	PR714 24 June 1812
960	1.0972					1014					1.0806
962					1.0820	1018					1.0781
966					1.0769	1022					1.0770
970	1.0936				1.0729	1026					1.0816
974					1.0729	1030					1.0728
978					1.0765	1034					1.0657
980	1.0924					1038					1.0715
982					1.0786	1042					1.0620
986					1.0783	1046					1.0576
990	1.0919				1.0791	1050					1.0586
994					1.0805	1054					1.0652
998					1.0808	1058					1.0767
1000	1.0904					1062					1.0608
1002					1.0832	1066					1.0715
1006					1.0838	1070					1.0521
1010					1.0809						

(1,000 nm). Below 420 nm, where PR714 radiances are up to 20% lower, the 746/ISIC log indicates the data were “very noisy below 450 nm.” SXR measurements do little to clarify these large discrepancies in radiance estimates for this sphere; they exceed PR714 radiances by 3–5%, and are approximately 1–2% less than 746/ISIC radiances (excluding 410.5 nm where the 746/ISIC data are clearly unreliable).

3.2.5 The WFF Sphere

The WFF sphere has two lamps which are operated simultaneously. When stating that the aperture is *open* or that a specific aperture number was used, this refers to both lamps. Spectral radiance of the WFF sphere was measured with the 746/ISIC (F269) on 18 June 1993 (open, *No. 3*, and *No. 5* apertures); the PR714 on 21 June (open, *No. 3*, *No. 5*, and *No. 6* apertures) and 23 June (open); the BSIXR on 18 June (open); and the SXR on 21 June (open, *No. 3*, *No. 5*, and *No. 6* apertures) and 23 June (open). The calibrated radiances from these measurements are listed in Table 18 and illustrated in Fig. 29. With open apertures, the PR714 radiances are approximately 2.5% higher on 21 June, and 3–5% higher on 23 June, than the 746/ISIC (F269) radiances on 18 June; the comparisons of *No. 3* and *No. 5* apertures also show the PR714 on 21 June to be higher, by approximately 2.5% and 1%, respectively. The BSIXR radiances (18 June) are also larger than those measured for this sphere on 18 June with the 746/ISIC (F269). SXR measurements of the WFF sphere on 21 and 23 June exceed 746/ISIC (18 June) by 3–6.5%, and exceed concurrent PR714 radiances by 0.5% up to almost 4%.

3.2.6 The NOAA Sphere

The spectral radiance of the NOAA Optronics 420M sphere radiance source was measured with the PR714 and the SXR, with 420M settings D40,S3,W6 (corresponding to particular settings of lamp location and aperture sizes) on 22 and 24 June 1993 and D100,S3,W5 on 22 June (Table 19 and Fig. 30). The three D40,S3,W6 radiance measurements from 22 and 24 June 1993 all agree to within less than 1%. SXR radiances for this sphere exceed PR714 radiances by 4–5.5% on 22 June 1993, and radiance differences on 24 June 1993 range from –5 to +3%.

3.3 Discussion

The initial indications of less than 1% apparent relative stability in the radiance scale of the GSFC sphere, as measured with the 746/ISIC (F269) on 15–19 June 1993, are very encouraging (Fig. 17). Measurements on subsequent days with the PR714, however, indicate apparent drifts in the radiance scale by as much as 3% (Figs. 19–21). Similar comparisons, based primarily on the PR714, also showed relatively large apparent day-to-day variabilities in the scales of some of the other spheres: BSI up to 5% (Fig. 22), CHORS up to 7% (Figs. 23–27) and WFF up to 5% (Fig. 29). However, the PR714 measurements of the Optronics 420M sphere on two days agreed with less than 1% (Fig. 30). From these data alone, it cannot be resolved whether apparent changes are actual measures of variability in sphere radiance, whether the PR714 itself is subject to wavelength dependent responsivity variations of

Table 15. The CHORS sphere (four 275 W lamps, all with apertures of 1.25) spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{ sr}^{-1}$] measured with the PR714, BSIXR, and SXR on 18 June 1993 (date and time are given in PDT). The 1805 and 1810 PR714 readings viewed the exit port 10° off axis, and the 1815 and 1820 radiances were measured on axis.

λ [nm]	BSIXR 1248	BSIXR 1411	BSIXR 1615	SXR 1804	PR714 1805	PR714† 1810	PR714 1815	PR714† 1820
382					0.3334	0.3326	0.3239	0.3214
386					0.3777	0.3732	0.3738	0.3739
390					0.4301	0.4232	0.4223	0.4221
394					0.4793	0.4850	0.4877	0.4819
398					0.5329	0.5357	0.5358	0.5372
402					0.5877	0.5871	0.5857	0.5826
406					0.6412	0.6409	0.6353	0.6345
410					0.6923	0.6925	0.6904	0.6920
411				0.7167				
412	0.7379	0.7385	0.7439					
414					0.7465	0.7442	0.7486	0.7494
418					0.8023	0.8018	0.8037	0.8026
422					0.8629	0.8620	0.8612	0.8620
426					0.9313	0.9315	0.9277	0.9289
430					0.9914	0.9909	0.9895	0.9892
434					1.0549	1.0558	1.0528	1.0548
438					1.1191	1.1215	1.1212	1.1196
441				1.1772				
442					1.1923	1.1944	1.1943	1.1934
443	1.2139	1.2130	1.2231					
446					1.2629	1.2637	1.2629	1.2646
450					1.3382	1.3375	1.3352	1.3355
454					1.4147	1.4163	1.4158	1.4134
458					1.4877	1.4889	1.4857	1.4850
462					1.5572	1.5568	1.5582	1.5568
466					1.6326	1.6337	1.6356	1.6346
470					1.7254	1.7218	1.7244	1.7247
474					1.8232	1.8186	1.8202	1.8205
478					1.9089	1.9104	1.9079	1.9084
482					1.9864	1.9875	1.9874	1.9865
486					2.0606	2.0626	2.0606	2.0587
487				2.1347				
490	2.1911	2.1851	2.1985		2.1544	2.1543	2.1554	2.1543
494					2.2583	2.2575	2.2593	2.2584
498					2.3588	2.3572	2.3568	2.3562
502					2.4432	2.4458	2.4411	2.4409
506					2.5165	2.5182	2.5165	2.5192
510					2.6049	2.6072	2.6069	2.6043
514					2.7065	2.7058	2.7075	2.7048
518					2.8011	2.8001	2.7980	2.8001
522					2.8964	2.8949	2.8924	2.8911
526					2.9824	2.9890	2.9854	2.9813
530					3.0634	3.0645	3.0644	3.0636
534					3.1458	3.1494	3.1479	3.1455
538					3.2441	3.2458	3.2461	3.2448
542					3.3351	3.3348	3.3310	3.3338

† Denotes corrected radiances measured with the large PR714 aperture.

Table 15. (cont.) The CHORS sphere (four 275 W lamps, all with apertures of 1.25) spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{ sr}^{-1}$] measured with the PR714, BSIXR, and SXR on 18 June 1993 (date and time are given in PDT). The 1805 and 1810 PR714 readings viewed the exit port 10° off axis, and the 1815 and 1820 radiances were measured on axis.

λ [nm]	BSIXR 1248	BSIXR 1411	BSIXR 1615	SXR 1804	PR714 1805	PR714† 1810	PR714 1815	PR714† 1820
546					3.4187	3.4186	3.4187	3.4205
547				3.4846				
550					3.4978	3.4973	3.5008	3.4973
554					3.5761	3.5763	3.5741	3.5753
558					3.6657	3.6669	3.6627	3.6622
562					3.7463	3.7501	3.7483	3.7472
566					3.8349	3.8358	3.8328	3.8319
570					3.9182	3.9219	3.9182	3.9170
574					3.9888	3.9931	3.9909	3.9921
578					4.0576	4.0558	4.0576	4.0558
582					4.1237	4.1236	4.1248	4.1227
586					4.2073	4.2032	4.2042	4.2051
589	4.2389	4.2353	4.2454					
590					4.2920	4.2895	4.2890	4.2934
594					4.3756	4.3729	4.3746	4.3748
598					4.4459	4.4480	4.4469	4.4403
602					4.5007	4.5041	4.4997	4.4992
606					4.5460	4.5483	4.5450	4.5415
610					4.5998	4.6025	4.5977	4.5996
614					4.6696	4.6713	4.6696	4.6683
618					4.7418	4.7422	4.7418	4.7402
622					4.8251	4.8214	4.8261	4.8195
626					4.9051	4.8987	4.9010	4.9026
630					4.9666	4.9641	4.9616	4.9592
634					4.9990	4.9992	4.9970	4.9943
638					5.0164	5.0172	5.0164	5.0133
642					5.0468	5.0472	5.0399	5.0385
646					5.0783	5.0781	5.0763	5.0722
650					5.1226	5.1282	5.1306	5.1205
654					5.2102	5.2183	5.2173	5.2095
656	5.2132	5.2110	5.2183					
658					5.3101	5.3101	5.3111	5.3072
661				5.5261				
662					5.4038	5.3997	5.4008	5.3978
666					5.4590	5.4595	5.4641	5.4595
670					5.4915	5.4918	5.4894	5.4889
674					5.4936	5.4939	5.4916	5.4890
678					5.4909	5.4934	5.4899	5.4895
682					5.4821	5.4813	5.4771	5.4804
683	5.4888	5.4762	5.4807					
686					5.4819	5.4840	5.4809	5.4869
690					5.5297	5.5320	5.5286	5.5282
694					5.6032	5.6049	5.5972	5.5991
698					5.6875	5.6915	5.6915	5.6896
702					5.7828	5.7833	5.7849	5.7793
706					5.8669	5.8679	5.8700	5.8659

† Denotes corrected radiances measured with the large PR714 aperture.

Table 15. (cont.) The CHORS sphere (four 275 W lamps, all with apertures of 1.25) spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{ sr}^{-1}$] measured with the PR714, BSIXR, and SXR on 18 June 1993 (date and time are given in PDT). The 1805 and 1810 PR714 readings viewed the exit port 10° off axis, and the 1815 and 1820 radiances were measured on axis.

λ [nm]	BSIXR 1248	BSIXR 1411	BSIXR 1615	SXR 1804	PR714 1805	PR714† 1810	PR714 1815	PR714† 1820
710					5.9295	5.9226	5.9306	5.9276
714					5.9425	5.9386	5.9373	5.9406
718					5.8975	5.8935	5.8954	5.8976
722					5.8477	5.8516	5.8498	5.8486
726					5.8132	5.8193	5.8173	5.8143
730					5.7698	5.7703	5.7708	5.7703
734					5.7550	5.7572	5.7570	5.7543
738					5.7633	5.7592	5.7572	5.7621
742					5.7757	5.7757	5.7747	5.7776
746					5.8529	5.8559	5.8529	5.8531
750					5.9934	5.9897	5.9963	5.9935
754					6.1068	6.1064	6.1078	6.1045
758					6.1463	6.1420	6.1433	6.1450
762					6.0837	6.0843	6.0827	6.0824
766					6.0680	6.0623	6.0630	6.0594
770					6.0640	6.0646	6.0630	6.0616
772				6.1470				
774					6.0291	6.0293	6.0251	6.0234
778					5.9693	5.9730	5.9754	5.9700
782					5.9255	5.9232	5.9215	5.9212
786					5.9113	5.9051	5.9061	5.9081
790					5.9135	5.9111	5.9094	5.9160
794					5.9209	5.9202	5.9240	5.9222
798					5.9493	5.9475	5.9504	5.9535
802					5.9999	5.9975	6.0019	5.9955
806					6.0372	6.0357	6.0393	6.0347
810					6.0625	6.0570	6.0615	6.0570
814					6.0686	6.0597	6.0645	6.0655
818					6.0714	6.0697	6.0653	6.0726
822					6.0478	6.0481	6.0489	6.0471
826					6.0130	6.0082	6.0160	6.0073
830					5.9739	5.9679	5.9779	5.9709
834					5.9290	5.9240	5.9290	5.9260
838					5.8855	5.8764	5.8753	5.8774
842					5.8436	5.8382	5.8436	5.8422
846					5.8148	5.8148	5.8179	5.8128
850					5.8056	5.8061	5.8098	5.8041
854					5.8057	5.8045	5.8109	5.8065
858					5.8457	5.8380	5.8384	5.8380
862					5.8920	5.8841	5.8836	5.8912
866					5.9158	5.9080	5.9127	5.9161
870					5.9403	5.9308	5.9382	5.9389
874					5.9585	5.9560	5.9616	5.9570
878					5.9539	5.9495	5.9570	5.9536
882					5.9413	5.9368	5.9330	5.9358
886					5.9204	5.9107	5.9080	5.9127

† Denotes corrected radiances measured with the large PR714 aperture.

Table 15. (cont.) The CHORS sphere (four 275 W lamps, all with apertures of 1.25) spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{ sr}^{-1}$] measured with the PR714, BSIXR, and SXR on 18 June 1993 (date and time are given in PDT). The 1805 and 1810 PR714 readings viewed the exit port 10° off axis, and the 1815 and 1820 radiances were measured on axis.

λ [nm]	BSIXR 1248	BSIXR 1411	BSIXR 1615	SXR 1804	PR714 1805	PR714† 1810	PR714 1815	PR714† 1820
890					5.8586	5.8508	5.8524	5.8588
894					5.7335	5.7301	5.7407	5.7411
898					5.5584	5.5524	5.5615	5.5544
902					5.3363	5.3324	5.3292	5.3264
906					5.1474	5.1440	5.1413	5.1469
910					5.0978	5.1025	5.0917	5.0938
914					5.2635	5.2575	5.2646	5.2633
918					5.4774	5.4731	5.4703	5.4711
922					5.6566	5.6541	5.6556	5.6658
926					5.7958	5.7851	5.7948	5.8058
930					5.8322	5.8364	5.8486	5.8403
934					5.8302	5.8281	5.8271	5.8301
938					5.8459	5.8487	5.8470	5.8527
942					5.8883	5.8739	5.8852	5.8820
946					5.8965	5.8954	5.9058	5.8864
950					5.9226	5.9181	5.9299	5.9291
954					5.9450	5.9396	5.9523	5.9547
958					5.9988	5.9776	6.0102	6.0048
962					6.0360	6.0224	6.0370	6.0355
966					6.0543	6.0354	6.0470	6.0464
970					6.0726	6.0578	6.0664	6.0679
974					6.0885	6.0740	6.0729	6.0790
978					6.1013	6.1113	6.1211	6.1093
982					6.1285	6.1181	6.1253	6.1222
986					6.1068	6.1000	6.1100	6.0919
990					6.0881	6.0832	6.0808	6.0873
994					6.0739	6.0655	6.0687	6.0625
998					6.0295	6.0162	6.0085	6.0335
1002					5.9707	5.9670	6.0042	5.9711
1006					5.9446	5.9381	5.9436	5.9340
1010					5.8827	5.8687	5.8597	5.8677
1014					5.8036	5.8012	5.7777	5.7982
1018					5.7480	5.7458	5.7469	5.7298
1022					5.7312	5.7298	5.7280	5.7189
1026					5.7267	5.7414	5.7318	5.7354
1030					5.7408	5.7571	5.7377	5.7353
1034					5.7841	5.7751	5.7779	5.7771
1038					5.8396	5.8349	5.8272	5.8148
1042					5.8268	5.8400	5.7948	5.8330
1046					5.8045	5.8174	5.7922	5.7818
1050					5.7832	5.8282	5.8204	5.8193
1054					5.8087	5.8653	5.8358	5.8371
1058					5.8196	5.8540	5.8290	5.8437
1062					5.8318	5.7626	5.8044	5.7657
1066					5.8103	5.7511	5.7405	5.8373
1070					5.7531	5.7551	5.7449	5.7419

† Denotes corrected radiances measured with the large PR714 aperture.

Table 16. The CHORS sphere (four 275 W lamps, all with apertures of 1.25) spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{ sr}^{-1}$] measured with the 746/ISIC, PR714, BSIXR, and SXR on 19 and 23 June 1993 (date and time given in PDT).

λ [nm]	PR714 1045	PR714† 1046	SXR 1047	PR714 1048	PR714† 1050	BSIXR 1100	746 1232	SXR 1357	PR714 1410	PR714† 0950	PR714‡ 1050§	PR714‡ 1611
350							0.0869					
360							0.1638					
370							0.2094					
380							0.2641					
382	0.3255	0.3273		0.3249	0.3263				0.3277	0.3323	0.3374	0.3482
386	0.3737	0.3798		0.3815	0.3798				0.3643	0.3860	0.3817	0.4006
390	0.4270	0.4244		0.4197	0.4290		0.3461		0.4214	0.4396	0.4429	0.4582
394	0.4793	0.4824		0.4854	0.4824				0.4898	0.5023	0.5094	0.5159
398	0.5307	0.5347		0.5412	0.5329				0.5395	0.5537	0.5593	0.5701
400							0.4413					
402	0.5822	0.5881		0.5893	0.5871				0.5928	0.6053	0.6152	0.6296
406	0.6386	0.6418		0.6437	0.6418				0.6466	0.6648	0.6700	0.6816
410	0.6930	0.6918		0.6976	0.6968		0.7060		0.6942	0.7188	0.7192	0.7340
412						0.7365						
411			0.7182					0.7228				
414	0.7441	0.7460		0.7497	0.7494				0.7494	0.7723	0.7799	0.7945
418	0.8059	0.8051		0.8049	0.8073				0.8087	0.8340	0.8392	0.8573
420							0.8436					
422	0.8629	0.8644		0.8666	0.8652				0.8668	0.8927	0.8995	0.9185
426	0.9292	0.9288		0.9339	0.9329				0.9298	0.9574	0.9639	0.9879
430	0.9938	0.9938		0.9942	0.9949		1.0024		0.9939	1.0275	1.0317	1.0564
434	1.0570	1.0558		1.0623	1.0608				1.0591	1.0937	1.1000	1.1231
438	1.1243	1.1235		1.1284	1.1283				1.1273	1.1594	1.1677	1.1915
440							1.1630					
441			1.1796					1.1864				
442	1.1974	1.1954		1.1994	1.2002				1.1984	1.2337	1.2397	1.2589
443						1.2133						
446	1.2649	1.2656		1.2709	1.2676				1.2689	1.3094	1.3145	1.3367
450	1.3362	1.3395		1.3433	1.3405		1.3390		1.3403	1.3853	1.3904	1.4180
454	1.4168	1.4193		1.4240	1.4223				1.4219	1.4631	1.4714	1.4992
458	1.4929	1.4899		1.4949	1.4977				1.4918	1.5309	1.5411	1.5679
460							1.5376					
462	1.5623	1.5617		1.5653	1.5674				1.5643	1.6030	1.6112	1.6407
466	1.6366	1.6366		1.6435	1.6432				1.6386	1.6903	1.6953	1.7242
470	1.7284	1.7314		1.7333	1.7333		1.7458		1.7284	1.7859	1.7889	1.8217
474	1.8242	1.8274		1.8293	1.8303				1.8283	1.8828	1.8858	1.9222
478	1.9151	1.9164		1.9213	1.9184				1.9151	1.9626	1.9729	2.0048
480							1.9578					
482	1.9905	1.9924		1.9968	1.9944				1.9905	2.0372	2.0507	2.0829
486	2.0658	2.0674		2.0730	2.0713				2.0668	2.1163	2.1317	2.1667
487			2.1333					2.1438				
490	2.1594	2.1601		2.1665	2.1668	2.1976	2.1814		2.1604	2.2269	2.2329	2.2671
494	2.2653	2.2670		2.2713	2.2718				2.2633	2.3339	2.3389	2.3737
498	2.3627	2.3659		2.3677	2.3668				2.3607	2.4263	2.4293	2.4651
500							2.4115					
502	2.4492	2.4497		2.4552	2.4526				2.4472	2.5044	2.5114	2.5496

† Denotes corrected radiances measured with the large PR714 aperture; all others were measured with the small aperture.

‡ Radiances measured on 23 June 1993; all other measurements were taken on 19 June 1993.

§ On 23 June, the 1050 PDT PR714 radiances were measured 20° off axis.

Table 16. (cont.) The CHORS sphere (four 275 W lamps, all with apertures of 1.25) spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{ sr}^{-1}$] measured with the 746/ISIC, PR714, BSIXR, and SXR on 19 and 23 June 1993 (date and time given in PDT).

λ [nm]	PR714 1045	PR714† 1046	SXR 1047	PR714 1048	PR714† 1050	BSIXR 1100	746 1232	SXR 1357	PR714 1410	PR714† 0950	PR714‡ 1050§	PR714† 1611
506	2.5226	2.5211		2.5307	2.5280				2.5256	2.5824	2.5916	2.6301
510	2.6100	2.6111		2.6191	2.6180		2.6307		2.6110	2.6750	2.6872	2.7259
514	2.7065	2.7078		2.7136	2.7155				2.7105	2.7856	2.7937	2.8404
518	2.8021	2.8030		2.8131	2.8107				2.8021	2.8806	2.8856	2.9320
520							2.8737					
522	2.9023	2.9064		2.9113	2.9103				2.9004	2.9712	2.9792	3.0221
526	2.9953	2.9948		3.0003	2.9987				2.9874	3.0608	3.0648	3.1085
530	3.0704	3.0714		3.0804	3.0791		3.0858		3.0694	3.1374	3.1474	3.1953
534	3.1509	3.1533		3.1641	3.1602				3.1509	3.2249	3.2370	3.2897
538	3.2461	3.2487		3.2584	3.2547				3.2461	3.3278	3.3401	3.3891
540							3.3109					
542	3.3351	3.3357		3.3454	3.3426				3.3331	3.4149	3.4241	3.4814
546	3.4239	3.4215		3.4300	3.4302				3.4208	3.5026	3.5077	3.5660
547			3.4896					3.5078				
550	3.5058	3.5088		3.5139	3.5146		3.5314		3.5028	3.5873	3.5924	3.6437
554	3.5860	3.5877		3.5949	3.5916				3.5791	3.6711	3.6741	3.7255
558	3.6716	3.6756		3.6816	3.6775				3.6667	3.7559	3.7628	3.8173
560							3.7387					
562	3.7553	3.7569		3.7682	3.7637				3.7493	3.8479	3.8460	3.9018
566	3.8409	3.8407		3.8499	3.8494				3.8359	3.9261	3.9332	3.9853
570	3.9202	3.9200		3.9314	3.9288		3.9328		3.9152	4.0065	4.0126	4.0694
574	3.9960	3.9921		4.0031	4.0010				3.9868	4.0795	4.0897	4.1447
578	4.0627	4.0636		4.0678	4.0705				4.0576	4.1577	4.1648	4.2220
580							4.1285					
582	4.1308	4.1324		4.1390	4.1392				4.1258	4.2285	4.2417	4.3017
586	4.2093	4.2147		4.2234	4.2204				4.2052	4.3209	4.3219	4.3872
589						4.2458						
590	4.3039	4.3020		4.3148	4.3144		4.3384		4.2900	4.4132	4.4112	4.4717
594	4.3865	4.3901		4.3973	4.3968				4.3746	4.4900	4.4841	4.5492
598	4.4538	4.4585		4.4607	4.4605				4.4410	4.5465	4.5484	4.6066
600							4.4712					
602	4.5106	4.5137		4.5225	4.5157				4.4947	4.6020	4.6039	4.6595
606	4.5519	4.5542		4.5620	4.5600				4.5370	4.6519	4.6479	4.7119
610	4.6048	4.6035		4.6158	4.6133		4.6186		4.5927	4.7225	4.7215	4.7860
614	4.6717	4.6762		4.6838	4.6781				4.6656	4.8098	4.8058	4.8769
618	4.7429	4.7471		4.7572	4.7539				4.7367	4.8847	4.8868	4.9643
620							4.8398					
622	4.8312	4.8341		4.8353	4.8419				4.8220	4.9656	4.9677	5.0481
626	4.9111	4.9143		4.9182	4.9192				4.8990	5.0349	5.0338	5.1058
630	4.9747	4.9864		4.9888	4.9825		4.9781		4.9595	5.0796	5.0756	5.1432
634	5.0100	5.0234		5.0280	5.0176				4.9950	5.1031	5.0991	5.1662
638	5.0244	5.0336		5.0393	5.0317				5.0005	5.1209	5.1129	5.1816
640							5.0290					
642	5.0438	5.0511		5.0548	5.0491				5.0219	5.1532	5.1532	5.2199
646	5.0763	5.0839		5.0873	5.0848				5.0514	5.2012	5.2032	5.2771
650	5.1286	5.1369		5.1366	5.1321		5.1764		5.1116	5.2775	5.2884	5.3574

† Denotes corrected radiances measured with the large PR714 aperture; all others were measured with the small aperture.

‡ Radiances measured on 23 June 1993; all other measurements were taken on 19 June 1993.

§ On 23 June, the 1050 PDT PR714 radiances were measured 20° off axis.

Table 16. (cont.) The CHORS sphere (four 275 W lamps, all with apertures of 1.25) spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{ sr}^{-1}$] measured with the 746/ISIC, PR714, BSIXR, and SXR on 19 and 23 June 1993 (date and time given in PDT).

λ [nm]	PR714 1045	PR714† 1046	SXR 1047	PR714 1048	PR714† 1050	BSIXR 1100	746 1232	SXR 1357	PR714 1410	PR714† 0950	PR714‡ 1050§	PR714† 1611
654	5.2193	5.2192		5.2263	5.2261				5.1982	5.3760	5.3800	5.4694
656						5.2044						
658	5.3081	5.3208		5.3303	5.3208				5.3021	5.4686	5.4757	5.5625
660							5.4263					
661			5.5395					5.5672				
662	5.4069	5.4173		5.4180	5.4154				5.3937	5.5538	5.5507	5.6328
666	5.4783	5.4840		5.4844	5.4821				5.4580	5.5829	5.5951	5.6774
670	5.5077	5.5133		5.5199	5.5153		5.5252		5.4844	5.5919	5.5919	5.6741
674	5.5097	5.5153		5.5208	5.5182				5.4846	5.5902	5.5801	5.6576
678	5.5089	5.5079		5.5158	5.5137				5.4799	5.5868	5.5748	5.6548
680							5.4884					
682	5.4871	5.4891		5.4980	5.4929				5.4641	5.5909	5.5869	5.6747
683						5.4807						
686	5.4878	5.4917		5.5067	5.4946				5.4650	5.6340	5.6230	5.7066
690	5.5326	5.5427		5.5516	5.5398		5.5938		5.5097	5.7090	5.6980	5.7817
694	5.6082	5.6059		5.6152	5.6136				5.5882	5.7845	5.7885	5.8757
698	5.7006	5.6993		5.7016	5.7013				5.6784	5.8833	5.8904	5.9822
700							5.8476					
702	5.7920	5.7981		5.7981	5.7971				5.7696	5.9803	5.9752	6.0647
706	5.8762	5.8849		5.8854	5.8799				5.8494	6.0436	6.0385	6.1248
710	5.9399	5.9508		5.9472	5.9467		5.9949		5.9119	6.0746	6.0653	6.1586
714	5.9550	5.9599		5.9643	5.9599				5.9186	6.0599	6.0495	6.1358
718	5.9110	5.9188		5.9246	5.9188				5.8788	5.9932	5.9943	6.0754
720							5.8917					
722	5.8612	5.8678		5.8758	5.8667				5.8247	5.9404	5.9415	6.0196
726	5.8277	5.8344		5.8380	5.8283				5.7894	5.9219	5.9209	5.9996
730	5.7790	5.7871		5.7903	5.7822		5.8039		5.7492	5.9114	5.9062	5.9976
734	5.7590	5.7651		5.7662	5.7612				5.7253	5.9245	5.9194	6.0144
738	5.7592	5.7679		5.7714	5.7621				5.7299	5.9587	5.9527	6.0458
740							5.8543					
742	5.7697	5.7795		5.7857	5.7738				5.7418	5.9916	5.9826	6.0815
746	5.8559	5.8616		5.8609	5.8521				5.8221	6.0746	6.0706	6.1740
750	5.9894	6.0059		6.0053	5.9954		6.2021		5.9616	6.2089	6.2069	6.3013
754	6.1088	6.1180		6.1187	6.1142				6.0729	6.3139	6.3060	6.3906
758	6.1533	6.1606		6.1603	6.1547				6.1103	6.3255	6.3185	6.4026
760							6.1891					
762	6.0968	6.1058		6.1048	6.0950				6.0446	6.2404	6.2193	6.3066
766	6.0750	6.0905		6.0861	6.0798				6.0259	6.1985	6.1834	6.2617
770	6.0760	6.0851		6.0871	6.0793		6.1731		6.0228	6.1814	6.1644	6.2467
772			6.1738					6.1878				
774	6.0412	6.0519		6.0493	6.0401				5.9869	6.1428	6.1277	6.2143
778	5.9885	5.9947		5.9946	5.9898				5.9339	6.1078	6.0916	6.1846
780							6.0297					
782	5.9276	5.9460		5.9449	5.9291				5.8849	6.0770	6.0689	6.1573
786	5.9113	5.9210		5.9194	5.9141				5.8683	6.0759	6.0729	6.1710
790	5.9176	5.9160		5.9186	5.9150		6.0303		5.8694	6.1062	6.1000	6.2015

† Denotes corrected radiances measured with the large PR714 aperture; all others were measured with the small aperture.

‡ Radiances measured on 23 June 1993; all other measurements were taken on 19 June 1993.

§ On 23 June, the 1050 PDT PR714 radiances were measured 20° off axis.

Table 16. (cont.) The CHORS sphere (four 275 W lamps, all with apertures of 1.25) spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{ sr}^{-1}$] measured with the 746/ISIC, PR714, BSIXR, and SXR on 19 and 23 June 1993 (date and time given in PDT).

λ [nm]	PR714 1045	PR714† 1046	SXR 1047	PR714 1048	PR714† 1050	BSIXR 1100	746 1232	SXR 1357	PR714 1410	PR714† 0950	PR714‡ 1050§	PR714‡ 1611
794	5.9188	5.9291		5.9270	5.9183				5.8818	6.1418	6.1388	6.2405
798	5.9432	5.9495		5.9514	5.9446				5.9050	6.1821	6.1790	6.2841
800							6.1389					
802	5.9865	5.9975		5.9968	5.9935				5.9495	6.2311	6.2270	6.3307
806	6.0301	6.0406		6.0362	6.0318				5.9863	6.2685	6.2512	6.3602
810	6.0524	6.0629		6.0625	6.0629		6.2109		6.0056	6.2729	6.2607	6.3674
814	6.0615	6.0724		6.0686	6.0655				6.0047	6.2642	6.2480	6.3413
818	6.0724	6.0755		6.0754	6.0667				6.0078	6.2421	6.2320	6.3158
820							6.1722					
822	6.0549	6.0617		6.0539	6.0481				5.9893	6.2073	6.1972	6.2860
826	6.0150	6.0297		6.0201	6.0190				5.9525	6.1591	6.1480	6.2357
830	5.9769	5.9963		5.9869	5.9816		6.0630		5.9115	6.1178	6.1047	6.1862
834	5.9320	5.9446		5.9391	5.9348				5.8653	6.0766	6.0584	6.1463
838	5.8906	5.8990		5.8936	5.8912				5.8276	6.0348	6.0175	6.1090
840							5.9524					
842	5.8569	5.8669		5.8569	5.8541				5.7866	6.0097	5.9934	6.0821
846	5.8219	5.8327		5.8271	5.8218				5.7594	6.0002	5.9808	6.0699
850	5.8118	5.8221		5.8191	5.8141		5.9036		5.7581	5.9875	5.9854	6.0764
854	5.8067	5.8185		5.8181	5.8125				5.7509	5.9962	5.9920	6.0924
858	5.8384	5.8471		5.8395	5.8390				5.7760	6.0454	6.0277	6.1255
860							6.0167					
862	5.8752	5.8831		5.8868	5.8790				5.8185	6.0778	6.0663	6.1733
866	5.9011	5.9121		5.9127	5.9070				5.8403	6.1045	6.0888	6.1958
870	5.9278	5.9409		5.9362	5.9328		6.0857		5.8631	6.1333	6.1146	6.2168
874	5.9480	5.9630		5.9595	5.9519				5.8781	6.1504	6.1316	6.2245
878	5.9434	5.9596		5.9549	5.9455				5.8745	6.1324	6.1073	6.2023
880							6.0560					
882	5.9340	5.9468		5.9423	5.9317				5.8520	6.1094	6.0855	6.1717
886	5.9142	5.9257		5.9173	5.9107				5.8296	6.0742	6.0463	6.1382
890	5.8576	5.8658		5.8617	5.8538		5.9406		5.7711	6.0120	5.9842	6.0768
894	5.7345	5.7431		5.7478	5.7431				5.6548	5.8952	5.8593	5.9483
898	5.5523	5.5694		5.5656	5.5614				5.4810	5.7102	5.6755	5.7621
900							5.3204					
902	5.3404	5.3523		5.3445	5.3393				5.2540	5.4807	5.4421	5.5376
906	5.1575	5.1685		5.1616	5.1489				5.0774	5.2924	5.2579	5.3482
910	5.1008	5.1083		5.1099	5.0957		5.1273		5.0188	5.2355	5.2031	5.2952
914	5.2625	5.2749		5.2706	5.2652				5.1846	5.4012	5.3779	5.4781
918	5.4713	5.4789		5.4815	5.4779				5.3964	5.6243	5.5990	5.7013
920							5.9934					
922	5.6647	5.6716		5.6759	5.6609				5.5725	5.8198	5.7945	5.8786
926	5.7958	5.8058		5.8060	5.7949				5.7092	5.9485	5.9373	6.0238
930	5.8373	5.8543		5.8527	5.8393		6.0282		5.7523	5.9898	5.9826	6.0799
934	5.8178	5.8281		5.8271	5.8152				5.7241	5.9847	5.9858	6.0692
938	5.8376	5.8507		5.8552	5.8337				5.7642	6.0053	6.0115	6.0850
940							6.0221					
942	5.8655	5.8910		5.8883	5.8810				5.7744	6.0292	6.0530	6.1317

† Denotes corrected radiances measured with the large PR714 aperture; all others were measured with the small aperture.

‡ Radiances measured on 23 June 1993; all other measurements were taken on 19 June 1993.

§ On 23 June, the 1050 PDT PR714 radiances were measured 20° off axis.

Table 16. (cont.) The CHORS sphere (four 275 W lamps, all with apertures of 1.25) spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{ sr}^{-1}$] measured with the 746/ISIC, PR714, BSIXR, and SXR on 19 and 23 June 1993 (date and time given in PDT).

λ [nm]	PR714 1045	PR714† 1046	SXR 1047	PR714 1048	PR714† 1050	BSIXR 1100	746 1232	SXR 1357	PR714 1410	PR714† 0950	PR714† 1050§	PR714† 1611
946	5.8809	5.8974		5.8933	5.8974				5.7968	6.0470	6.0761	6.1425
950	5.9112	5.9100		5.9195	5.9271		6.0701		5.8309	6.0893	6.0987	6.1685
954	5.9366	5.9447		5.9481	5.9427				5.8584	6.1066	6.1108	6.1984
958	5.9769	6.0007		5.9862	5.9897				5.8935	6.1487	6.1394	6.2290
960							6.2051					
962	6.0142	6.0284		6.0266	6.0274				5.9173	6.1890	6.1765	6.2754
966	6.0366	6.0474		6.0418	6.0504				5.9492	6.2146	6.2000	6.2843
970	6.0747	6.0790		6.0643	6.0729		6.3202		5.9746	6.2248	6.2227	6.3134
974	6.0708	6.0851		6.0791	6.0740				5.9763	6.2361	6.2340	6.3265
978	6.0961	6.1053		6.1065	6.0992				5.9939	6.2680	6.2649	6.3483
980							6.3125					
982	6.1138	6.1364		6.1264	6.1161				6.0225	6.2890	6.2775	6.3845
986	6.1037	6.1173		6.1089	6.1193				6.0156	6.2818	6.2473	6.3730
990	6.0850	6.0822		6.0871	6.0893		6.2275		5.9835	6.2765	6.2283	6.3413
994	6.0466	6.0696		6.0645	6.0553				5.9595	6.2440	6.2083	6.3227
998	6.0316	6.0437		6.0400	6.0162				5.9308	6.1912	6.1765	6.2993
1000							6.1083					
1002	5.9749	6.0037		5.9781	5.9864				5.8922	6.1508	6.1194	6.2378
1006	5.9299	5.9462		5.9383	5.9391				5.8355	6.1041	6.0695	6.1681
1010	5.8691	5.8708		5.8733	5.8778				5.7867	6.0268	6.0090	6.1155
1014	5.8056	5.8062		5.8180	5.8002				5.6950	5.9442	5.9401	6.0280
1018	5.7490	5.7878		5.7562	5.7358				5.6397	5.9253	5.8665	5.9706
1022	5.7353	5.7548		5.7280	5.7189				5.6071	5.8965	5.8438	5.9141
1026	5.7257	5.7255		5.7462	5.7284				5.6197	5.8677	5.8419	5.9376
1030	5.7305	5.7353		5.7614	5.7432				5.6347	5.8952	5.8571	5.9868
1034	5.7655	5.7771		5.7686	5.7681				5.6684	5.9340	5.8927	6.0157
1038	5.8200	5.8279		5.8003	5.8098				5.6989	5.9586	5.9369	6.0497
1042	5.8423	5.8220		5.8671	5.8360				5.7338	5.9869	5.9363	6.0169
1046	5.8312	5.8353		5.8580	5.8521				5.7099	5.9720	5.9628	6.0265
1050	5.8410	5.8382		5.8513	5.8103				5.7544	5.9514	6.0019	6.0638
1054	5.8744	5.8491		5.8734	5.8391				5.7408	6.0018	6.0645	6.0770
1058	5.8437	5.8785		5.8941	5.8090				5.7388	6.0138	6.0232	6.0568
1062	5.7390	5.8655		5.8339	5.8125				5.6895	5.9120	5.9194	6.0617
1066	5.8207	5.8110		5.8145	5.7846				5.6145	5.9447	5.8655	6.0905
1070	5.7769	5.7104		5.7056	5.7714				5.5704	5.9297	5.8337	5.9813

† Denotes corrected radiances measured with the large PR714 aperture; all others were measured with the small aperture.

‡ Radiances measured on 23 June 1993; all other measurements were taken on 19 June 1993.

§ On 23 June, the 1050 PDT PR714 radiances were measured 20° off axis.

Table 17. The UCSB sphere (illuminated with FEL lamp F303 at 50 cm) spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{ sr}^{-1}$], measured with the 746/ISIC, PR714 (large aperture; corrected), and the SXR on 21 June 1993. The PR714 measurement at 1822 PDT was taken with the UCSB sphere configured with a 2.54 cm entrance aperture; all others were measured with a 5.08 cm entrance aperture.

λ [nm]	746 1516	746 1520	SXR 1643	PR714† 1657	PR714† 1811	PR714† 1822
350	0.0144	0.0131				
360	0.0164	0.0166				
370	0.0190	0.0191				
380	0.0215	0.0224				
382				0.0235	0.0236	0.0063
386				0.0267	0.0273	0.0071
390	0.0261	0.0263		0.0295	0.0297	0.0078
394				0.0329	0.0337	0.0088
398				0.0350	0.0363	0.0094
400	0.0309	0.0314				
402				0.0376	0.0388	0.0101
406				0.0407	0.0418	0.0109
410	0.0363	0.0365		0.0436	0.0451	0.0117
411			0.0468			
414				0.0464	0.0478	0.0125
418				0.0495	0.0509	0.0133
420	0.0423	0.0430				
422				0.0524	0.0540	0.0141
426				0.0561	0.0579	0.0152
430	0.0627	0.0632		0.0595	0.0614	0.0161
434				0.0629	0.0648	0.0170
438				0.0664	0.0683	0.0179
440	0.0716	0.0720				
441			0.0712			
442				0.0707	0.0723	0.0190
446				0.0743	0.0762	0.0200
450	0.0818	0.0822		0.0778	0.0800	0.0210
454				0.0824	0.0846	0.0222
458				0.0861	0.0880	0.0231
460	0.0923	0.0926				
462				0.0896	0.0916	0.0240
466				0.0940	0.0957	0.0251
470	0.1032	0.1037		0.0986	0.1001	0.0263
474				0.1031	0.1050	0.0276
478				0.1084	0.1100	0.0289
480	0.1150	0.1154				
482				0.1128	0.1140	0.0299
486				0.1166	0.1178	0.0309
487			0.1217			
490	0.1266	0.1270		0.1212	0.1224	0.0321
494				0.1261	0.1273	0.0334
498				0.1311	0.1320	0.0347
500	0.1385	0.1390				
502				0.1356	0.1369	0.0359

† Denotes corrected radiances measured with the large PR714 aperture.

Table 17. (cont.) The UCSB sphere (illuminated with FEL lamp F303 at 50 cm) spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{ sr}^{-1}$], measured with the 746/ISIC, PR714 (large aperture; corrected), and the SXR on 21 June 1993. The PR714 measurement at 1822 PDT was taken with the UCSB sphere configured with a 2.54 cm entrance aperture; all others were measured with a 5.08 cm entrance aperture.

λ [nm]	746 1516	746 1520	SXR 1643	PR714† 1657	PR714† 1811	PR714† 1822
506				0.1396	0.1409	0.0370
510	0.1503	0.1510		0.1440	0.1451	0.0381
514				0.1491	0.1497	0.0394
518				0.1528	0.1537	0.0404
520	0.1621	0.1627				
522				0.1576	0.1588	0.0416
526				0.1625	0.1637	0.0430
530	0.1757	0.1757		0.1670	0.1680	0.0441
534				0.1715	0.1723	0.0453
538				0.1766	0.1774	0.0466
540	0.1870	0.1880				
542				0.1805	0.1816	0.0477
546				0.1847	0.1856	0.0487
547			0.1924			
550	0.1982	0.1992		0.1893	0.1902	0.0499
554				0.1932	0.1941	0.0509
558				0.1979	0.1987	0.0522
560	0.2091	0.2100				
562				0.2024	0.2034	0.0534
566				0.2070	0.2080	0.0546
570	0.2207	0.2207		0.2111	0.2121	0.0557
574				0.2153	0.2164	0.0568
578				0.2189	0.2199	0.0576
580	0.2307	0.2319				
582				0.2217	0.2227	0.0583
586				0.2260	0.2271	0.0594
590	0.2411	0.2411		0.2304	0.2315	0.0607
594				0.2345	0.2358	0.0619
598				0.2394	0.2405	0.0631
600	0.2508	0.2516				
602				0.2435	0.2444	0.0641
606				0.2459	0.2469	0.0649
610	0.2609	0.2617		0.2493	0.2505	0.0660
614				0.2524	0.2538	0.0667
618				0.2544	0.2560	0.0672
620	0.2706	0.2713				
622				0.2584	0.2597	0.0681
626				0.2627	0.2637	0.0691
630	0.2795	0.2807		0.2663	0.2676	0.0702
634				0.2700	0.2714	0.0712
638				0.2728	0.2739	0.0719
640	0.2875	0.2883				
642				0.2756	0.2770	0.0727
646				0.2783	0.2794	0.0734
650	0.2962	0.2970		0.2805	0.2813	0.0738

† Denotes corrected radiances measured with the large PR714 aperture.

Table 17. (cont.) The UCSB sphere (illuminated with FEL lamp F303 at 50 cm) spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{ sr}^{-1}$], measured with the 746/ISIC, PR714 (large aperture; corrected), and the SXR on 21 June 1993. The PR714 measurement at 1822 PDT was taken with the UCSB sphere configured with a 2.54 cm entrance aperture; all others were measured with a 5.08 cm entrance aperture.

λ [nm]	746 1516	746 1520	SXR 1643	PR714† 1657	PR714† 1811	PR714† 1822
654				0.2829	0.2837	0.0745
658				0.2855	0.2869	0.0752
660	0.3038	0.3046				
661			0.3032			
662				0.2902	0.2912	0.0763
666				0.2931	0.2943	0.0771
670	0.3111	0.3119		0.2958	0.2972	0.0777
674				0.2996	0.3006	0.0787
678				0.3020	0.3029	0.0794
680	0.3181	0.3190				
682				0.3030	0.3039	0.0797
686				0.3041	0.3058	0.0802
690	0.3242	0.3251		0.3062	0.3078	0.0807
694				0.3068	0.3079	0.0809
698				0.3094	0.3105	0.0815
700	0.3303	0.3316				
702				0.3125	0.3134	0.0823
706				0.3157	0.3162	0.0831
710	0.3369	0.3378		0.3192	0.3202	0.0841
714				0.3224	0.3236	0.0848
718				0.3245	0.3260	0.0853
720	0.3416	0.3426				
722				0.3272	0.3282	0.0860
726				0.3290	0.3304	0.0867
730	0.3473	0.3482		0.3291	0.3302	0.0867
734				0.3305	0.3316	0.0869
738				0.3312	0.3322	0.0871
740	0.3524	0.3534				
742				0.3290	0.3302	0.0866
746				0.3280	0.3291	0.0864
750	0.3569	0.3579		0.3302	0.3312	0.0870
754				0.3348	0.3359	0.0880
758				0.3388	0.3397	0.0891
760	0.3605	0.3615				
762				0.3384	0.3395	0.0891
766				0.3394	0.3403	0.0892
770	0.3647	0.3656		0.3417	0.3427	0.0898
772			0.3576			
774				0.3439	0.3450	0.0905
778				0.3447	0.3455	0.0908
780	0.3678	0.3688				
782				0.3440	0.3451	0.0908
786				0.3443	0.3454	0.0909
790	0.3699	0.3710		0.3458	0.3469	0.0912

† Denotes corrected radiances measured with the large PR714 aperture.

Table 17. (cont.) The UCSB sphere (illuminated with FEL lamp F303 at 50 cm) spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{ sr}^{-1}$], measured with the 746/ISIC, PR714 (large aperture; corrected), and the SXR on 21 June 1993. The PR714 measurement at 1822 PDT was taken with the UCSB sphere configured with a 2.54 cm entrance aperture; all others were measured with a 5.08 cm entrance aperture.

λ [nm]	746 1516	746 1520	SXR 1643	PR714† 1657	PR714† 1811	PR714† 1822
794				0.3449	0.3459	0.0909
798				0.3444	0.3454	0.0909
800	0.3726	0.3737				
802				0.3457	0.3469	0.0913
806				0.3466	0.3480	0.0917
810	0.3737	0.3748		0.3462	0.3477	0.0917
814				0.3468	0.3475	0.0918
818				0.3486	0.3493	0.0923
820	0.3738	0.3749				
822				0.3477	0.3489	0.0921
826				0.3466	0.3476	0.0918
830	0.3758	0.3769		0.3490	0.3500	0.0924
834				0.3490	0.3502	0.0926
838				0.3477	0.3488	0.0923
840	0.3760	0.3760				
842				0.3477	0.3491	0.0925
846				0.3491	0.3496	0.0929
850	0.3760	0.3772		0.3487	0.3495	0.0930
854				0.3482	0.3490	0.0929
858				0.3485	0.3493	0.0930
860	0.3768	0.3779				
862				0.3474	0.3488	0.0929
866				0.3462	0.3476	0.0926
870	0.3758	0.3769		0.3469	0.3482	0.0926
874				0.3487	0.3497	0.0931
878				0.3485	0.3498	0.0934
880	0.3757	0.3767				
882				0.3478	0.3491	0.0932
886				0.3476	0.3485	0.0932
890	0.3740	0.3750		0.3479	0.3489	0.0933
894				0.3495	0.3496	0.0936
898				0.3493	0.3503	0.0936
900	0.3734	0.3744				
902				0.3456	0.3465	0.0928
906				0.3411	0.3422	0.0916
910	0.3715	0.3725		0.3348	0.3363	0.0900
914				0.3319	0.3323	0.0892
918				0.3316	0.3329	0.0892
920	0.3690	0.3700				
922				0.3335	0.3346	0.0896
926				0.3343	0.3349	0.0898
930	0.3644	0.3654		0.3346	0.3348	0.0896
934				0.3329	0.3342	0.0894
938				0.3320	0.3330	0.0893
940	0.3607	0.3612				
942				0.3308	0.3317	0.0890

† Denotes corrected radiances measured with the large PR714 aperture.

Table 17. (cont.) The UCSB sphere (illuminated with FEL lamp F303 at 50 cm) spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{ sr}^{-1}$], measured with the 746/ISIC, PR714 (large aperture; corrected), and the SXR on 21 June 1993. The PR714 measurement at 1822 PDT was taken with the UCSB sphere configured with a 2.54 cm entrance aperture; all others were measured with a 5.08 cm entrance aperture.

λ [nm]	746 1516	746 1520	SXR 1643	PR714† 1657	PR714† 1811	PR714† 1822
946				0.3303	0.3311	0.0889
950	0.3596	0.3606		0.3291	0.3304	0.0885
954				0.3264	0.3279	0.0880
958				0.3268	0.3280	0.0880
960	0.3580	0.3590				
962				0.3266	0.3278	0.0880
966				0.3239	0.3253	0.0872
970	0.3562	0.3577		0.3231	0.3237	0.0869
974				0.3232	0.3234	0.0867
978				0.3230	0.3237	0.0869
980	0.3540	0.3550				
982				0.3234	0.3239	0.0871
986				0.3227	0.3233	0.0869
990	0.3514	0.3525		0.3212	0.3221	0.0868
994				0.3216	0.3227	0.0866
998				0.3205	0.3219	0.0865
1000	0.3491	0.3503				
1002				0.3192	0.3202	0.0861
1006				0.3202	0.3197	0.0860
1010				0.3190	0.3186	0.0855
1014				0.3171	0.3187	0.0853
1018				0.3146	0.3164	0.0846
1022				0.3147	0.3153	0.0846
1026				0.3136	0.3139	0.0841
1030				0.3121	0.3121	0.0839
1034				0.3090	0.3118	0.0836
1038				0.3113	0.3134	0.0841
1042				0.3090	0.3096	0.0835
1046				0.3044	0.3074	0.0818
1050				0.3051	0.3033	0.0814
1054				0.3068	0.3050	0.0821
1058				0.3066	0.3064	0.0822
1062				0.3026	0.3039	0.0825
1066				0.3062	0.3049	0.0837
1070				0.3030	0.3031	0.0816

† Denotes corrected radiances measured with the large PR714 aperture.

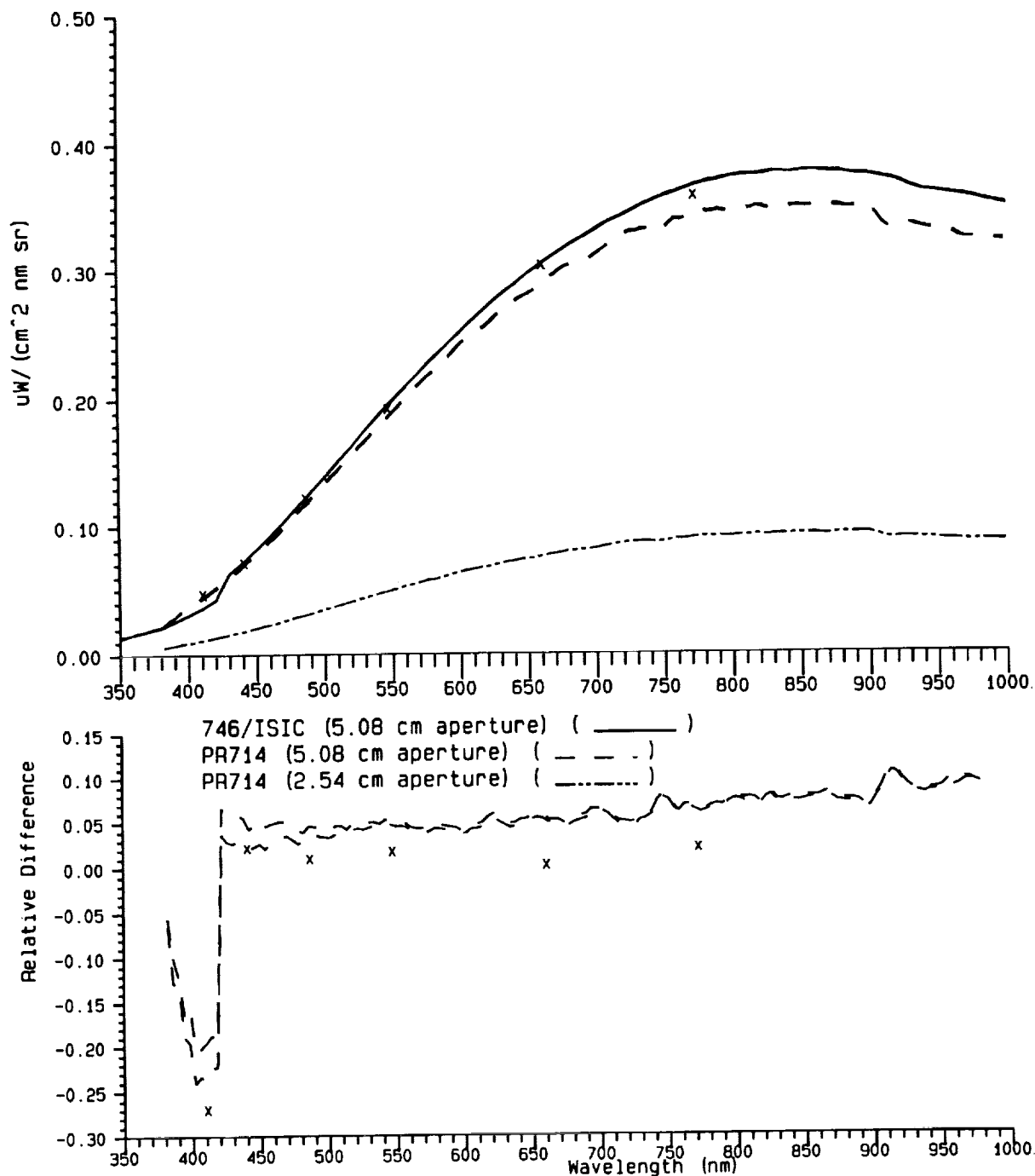


Fig. 28. Spectral radiance of the UCSB sphere, illuminated by FEL lamp F303 at 50 cm from the entrance aperture. Measured with a 5.08 cm entrance aperture with the 746/ISIC at 1516 and 1520 PDT, by the SXR at 1643 PDT (\times), and by the PR714 at 1567 and 1811 PDT on 21 June 1993. Measured with a 2.54 cm entrance aperture using the PR714 at 1822 PDT. The top panel illustrates spectral radiance ($\mu\text{W cm}^{-2} \text{ nm}^{-1} \text{ sr}^{-1}$) of the sphere, and the bottom panel illustrates the departures of the PR714 and SXR radiances (5.08 cm aperture only) relative to the 1520 746/ISIC spectrum.

Table 18. The WFF sphere (two lamps operated simultaneously, both with apertures open, *No. 3*, *No. 5*, and *No. 6* as indicated) spectral radiance [$\mu\text{W cm}^{-2}\text{nm}^{-1}\text{sr}^{-1}$] measured with the 746/ISIC, the PR714 (small aperture), and the BSIXR on 18, 21, and 23 June 1993; and the SXR on 21 and 23 June 1993 (date and time are in PDT).

[illegible]

† Measurements taken on 18 June 1993.

‡ Measurements taken on 21 June 1993.

§ Measurements taken on 23 June 1993.

Table 18. (cont.) The WFF sphere (two lamps operated simultaneously, both with apertures open, No. 3, No. 5, and No. 6 as indicated) spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{ sr}^{-1}$] measured with the 746/ISIC, the PR714 (small aperture), and the BSXR on 18, 21, and 23 June 1993; and the SXR on 21 and 23 June 1993 (date and time are in PDT).

λ [nm]	open 746	open BSXR	open PR714	open SXR	open PR714	open PR714	open PR714	open 746	3 PR714	3 SXR	5 746	5 PR714	5 SXR	6 PR714	6 SXR
462	1201†	1246†	1030†	1205†	1220†	1204†	1706§	2.6608	1.8058	1211†	1221†	1258†	1305†	1326†	1328†
466			2.6445	2.6364	2.6516	2.7953		2.6608	1.8058			0.8757		0.7048	
470	2.8472		2.7724	2.7834	2.7824	2.9405		2.7953	1.9004		0.9534	0.9181		0.7405	
474			2.9137	2.9157	2.9246	3.0868		2.9405	2.0014			0.9659		0.7803	
478			3.0585	3.0585	3.0687	3.2324		3.0868	2.1010			1.0161		0.8233	
480	3.1881		3.1995	3.2098	3.2159	3.3760		3.2324	2.1986		1.0680	1.0617		0.8609	
482			3.3397	3.3480	3.3636	3.5206		2.1916	2.2967			1.1053		0.8959	
486			3.4866	3.4907	3.5072	3.6217		3.5206	2.3862			1.1498		0.9304	
487				3.6042						2.4784			1.2023		0.9819
490	3.5452	3.6824	3.6413	3.6403	3.6494	3.6695		3.6695	2.4332	2.4916	1.1843	1.2010		0.9730	
494			3.7911	3.7990	3.8110	3.8209		3.8209	2.5923			1.2534		1.0159	
498			3.9422	3.9462	3.9641	3.9700		3.9700	2.6977			1.3021		1.0536	
500	3.9099							2.6806			1.3045				
502			4.0930	4.0980	4.1111	4.1281		4.1281	2.8016			1.3526		1.0965	
506			4.2374	4.2456	4.2537	4.2770		4.2770	2.8990			1.3993		1.1355	
510	4.2859		4.3984	4.4005	4.4198	4.4432		4.4432	3.0055		1.4253	1.4489		1.1753	
514			4.5564	4.5585	4.5666	4.5940		4.5940	3.1093			1.5019		1.2168	
518			4.7000	4.7030	4.7141	4.7433		4.7433	3.2118			1.5465		1.2535	
520	4.6683							3.1864			1.5492				
522			4.8545	4.8645	4.8755	4.8995		4.8995	3.3135			1.5939		1.2915	
526			5.0250	5.0279	5.0269	5.0597		5.0597	3.4201			1.6455		1.3349	
530	5.0423		5.1749	5.1789	5.1899	5.2219		5.2219	3.5223		1.6706	1.6967		1.3777	
534			5.3292	5.3342	5.3484	5.3778		5.3778	3.6332			1.7467		1.4174	
538			5.4922	5.5024	5.5096	5.5361		5.5361	3.7425			1.8018		1.4617	
540	5.4094							3.6853			1.7874				
542			5.6393	5.6445	5.6567	5.6854		5.6854	3.8393			1.8450		1.4952	
546			5.7885	5.7937	5.8100	5.8438		5.8438	3.9360			1.8914		1.5305	
547				6.0000						4.0899			1.9784		1.6183
550	5.7813		5.9366	5.9407	5.9568	5.9940		5.9940	4.0342		1.9071	1.9366		1.5702	
554			6.1010	6.1030	6.1050	6.1396		6.1396	4.1363			1.9845		1.6084	
558			6.2591	6.2591	6.2700	6.3047		6.3047	4.2435			2.0355		1.6520	

† Measurements taken on 18 June 1993.

‡ Measurements taken on 21 June 1993.

§ Measurements taken on 23 June 1993.

Table 18. (cont.) The WFF sphere (two lamps operated simultaneously, both with apertures open, *No. 3*, *No. 5*, and *No. 6* as indicated) spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{sr}^{-1}$] measured with the 746/ISIC, the PR714 (small aperture), and the BSXR on 18, 21, and 23 June 1993; and the SXR on 21 and 23 June 1993 (date and time are in PDT).

λ [nm]	open 746	open BSIXR 1201†	open PR714 1030†	open SXR 1205†	open PR714 1220†	open PR714 1705§	open SXR 1706§	open PR714 1715§	3 746 1211†	3 PR714 1223†	3 SXR 1239†	5 746 1221†	5 PR714 1258†	5 SXR 1305†	6 PR714 1326†	6 SXR 1328†
560	6.1490								4.1768			2.0250				
562			6.4156		6.4136	6.4196		6.4584		4.3461			2.0854		1.6948	
566			6.5522		6.5573	6.5653		6.6064		4.4457			2.1336		1.7334	
570	6.5042		6.7049		6.7090	6.7201		6.7587	4.4109	4.5474		2.1360	2.1768		1.7678	
574			6.8549		6.8528	6.8610		6.9099		4.6389			2.2211		1.8034	
578			6.9884		6.9986	7.0067		7.0517		4.7287			2.2637		1.8367	
580	6.8555								4.6438			2.2488				
582			7.1291		7.1352	7.1393		7.1891		4.8100			2.2988		1.8656	
586			7.2705		7.2745	7.2745		7.3288		4.8999			2.3434		1.9011	
589		7.2654														
590	7.1967		7.4142		7.4201	7.4221		7.4708	4.8646	5.0020		2.3516	2.3913		1.9395	
594			7.5577		7.5547	7.5695		7.6238		5.0967			2.4334		1.9777	
598			7.7030		7.7020	7.7089		7.7612		5.1873			2.4773		2.0130	
600	7.5229								5.0772			2.4517				
602			7.8420		7.8370	7.8320		7.8946		5.2760			2.5213		2.0478	
606			7.9627		7.9647	7.9667		8.0306		5.3564			2.5623		2.0796	
610	7.8457		8.1054		8.0974	8.1014		8.1578	5.2854	5.4442		2.5519	2.6049		2.1207	
614			8.2318		8.2359	8.2298		8.2938		5.5292			2.6447		2.1540	
618			8.3508		8.3518	8.3498		8.4263		5.6012			2.6771		2.1790	
620	8.1362								5.4879			2.6443				
622			8.4546		8.4546	8.4729		8.5310		5.6754			2.7099		2.2028	
626			8.5790		8.5821	8.5871		8.6541		5.7498			2.7461		2.2310	
630	8.4188		8.7052		8.7112	8.7243		8.7879	5.6765	5.8354		2.7327	2.7830		2.2603	
634			8.8448		8.8458	8.8538		8.9159		5.9189			2.8188		2.2933	
638			8.9609		8.9579	8.9599		9.0246		5.9948			2.8546		2.3261	
640	8.7045								5.8492			2.8193				
642			9.0791		9.0612	9.0672		9.1467		6.0653			2.8914		2.3563	
646			9.1939		9.1799	9.1919		9.2578		6.1399			2.9281		2.3839	
650	9.0076		9.3000		9.2920	9.3090		9.3689	6.0238	6.2167		2.9049	2.9604		2.4119	
654			9.4080		9.3999	9.4050		9.4853		6.2810			2.9943		2.4419	
656		9.2750														
658			9.5098		9.5118	9.5401		9.6097		6.3489			3.0256		2.4683	

† Measurements taken on 18 June 1993.

† Measurements taken on 21 June 1993.

§ Measurements taken on 23 June 1993.

Table 18. (cont.) The WFF sphere (two lamps operated simultaneously, both with apertures open, No. 3, No. 5, and No. 6 as indicated) spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{ sr}^{-1}$] measured with the 746/ISIC, the PR714 (small aperture), and the BSIXR on 18, 21, and 23 June 1993; and the SXR on 21 and 23 June 1993 (date and time are in PDT).

λ [nm]	open 746	open BSIXR	open PR714	open SXR	open PR714	open SXR	open PR714	open 746	3 1211†	3 1223‡	3 1239‡	5 1221†	5 1258‡	5 1305‡	6 1326‡	6 1328‡
660	9.2508								6.2149			2.9843				
661				9.8654							6.6051		3.0591	3.1641		2.5951
662		9.6262	9.6262	9.6464	9.7204					6.4252			3.0865		2.4906	
666		9.7348	9.7348	9.7531	9.8201					6.4909					2.5106	
670	9.5292	9.8392	9.8392	9.8483	9.8534					6.5571		3.0648	3.1106		2.5311	
674		9.9392	9.9392	9.9412	9.9553					6.6141			3.1401		2.5517	
678		10.0642	10.0642	10.0542	10.0642					6.6902			3.1792		2.5825	
680	9.8044								6.5462			3.1446				
682		10.1634	10.1634	10.1934	10.2732					6.7570			3.2118		2.6107	
683		10.0977														
686		10.2599	10.2599	10.2897	10.3891					6.8210			3.2370		2.6365	
690	10.0497	10.3799	10.3799	10.3700	10.3998					6.8994		3.2202	3.2704		2.6667	
694		10.4790	10.4790	10.4690	10.5091					6.9576			3.3000		2.6889	
698		10.5795	10.5795	10.5795	10.5996					7.0250			3.3354		2.7176	
700	10.3065								6.8710			3.2937				
702		10.6743	10.6743	10.7048	10.8066					7.0874			3.3641		2.7373	
706		10.7680	10.7680	10.8194	10.9118					7.1543			3.3938		2.7639	
710	10.5710	10.8724	10.8724	10.9242	11.0278					7.2158		3.3703	3.4203		2.7849	
714		10.9727	10.9727	11.0246	11.1389					7.2756			3.4497		2.8149	
718		11.0689	11.0689	11.1209	11.2249					7.3300			3.4705		2.8296	
720	10.7998								7.1884			3.4402				
722		11.1722	11.1722	11.1826	11.2451					7.4036			3.4996		2.8493	
726		11.2971	11.2971	11.3074	11.3489					7.4793			3.5403		2.8849	
730	11.0548	11.4122	11.4122	11.4122	11.4533					7.5432		3.5148	3.5704		2.9116	
734		11.5017	11.5017	11.5120	11.5528					7.6038			3.5925		2.9255	
738		11.6055	11.6055	11.6055	11.6562					7.6621			3.6184		2.9470	
740	11.3126								7.5085			3.5915				
742		11.6914	11.6914	11.7413	11.8413					7.7203			3.6413		2.9678	
746		11.7874	11.7874	11.7973	11.8470					7.7781			3.6724		2.9965	
750	11.5487	11.8695	11.8695	11.8695	11.9192					7.8309		3.6615	3.6969		3.0155	
754		11.9506	11.9506	11.9506	12.0004					7.8735			3.7147		3.0275	

† Measurements taken on 18 June 1993.

‡ Measurements taken on 21 June 1993.

§ Measurements taken on 23 June 1993.

Table 18. (cont.) The WFF sphere (two lamps operated simultaneously, both with apertures open, No. 3, No. 5, and No. 6 as indicated) spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{ sr}^{-1}$] measured with the 746/ISIC, the PR714 (small aperture), and the BSIXR on 18, 21, and 23 June 1993; and the SXR on 21 and 23 June 1993 (date and time are in PDT).

λ [nm]	open 746	open BSIXR	open PR714	open SXR	open PR714	open PR714	open SXR	open PR714	open 746	3 PR714	3 746	3 SXR	5 PR714	5 746	5 PR714	5 SXR	6 PR714	6 SXR
758		1201†	1246†	1030†	120204	120305	120905	1206§	12.2006	7.9189			3.7282				3.0346	
760	11.7222									7.7586				3.7106				
762					12.1494	12.1393	12.2096		12.3301	7.9875			3.7583				3.0624	
766					12.2303	12.2203	12.3006		12.4109	8.0405			3.7835				3.0862	
770	11.9773				12.2946	12.3046	12.3749		12.4853	7.9154	8.0763		3.7807	3.7998			3.0972	
772					12.5707			12.5537				8.2902				3.9330		3.2339
774					12.3641	12.3842	12.4546		12.5653	8.1207			3.8239				3.1137	
778					12.4723	12.4723	12.5329		12.6643	8.1838			3.8539				3.1383	
780	12.1542									8.0247			3.8356					
782					12.5321	12.5321	12.6134		12.7252	8.2196			3.8704				3.1528	
786					12.5998	12.6100	12.7021		12.8043	8.2717			3.8924				3.1714	
790	12.3142				12.6797	12.6797	12.7720		12.8745	8.3161			3.8763	3.9126			3.1920	
794					12.7338	12.7338	12.8263		12.9496	8.3412			3.9229				3.1973	
798					12.7618	12.7721	12.8751		12.9781	8.3513			3.9254				3.2013	
800	12.4406									8.1898			3.9096					
802					12.8238	12.8341	12.9368		13.0293	8.3899			3.9406				3.2142	
806					12.8692	12.8794	12.9711		13.0934	8.4266			3.9606				3.2321	
810	12.5689				12.9076	12.9178	13.0296		13.1414	8.4489			3.9399	3.9678			3.2422	
814					12.9483	12.9584	13.0699		13.1612	8.4716			3.9767				3.2447	
818					13.0072	13.0274	13.1183		13.2395	8.5092			3.9971				3.2629	
820	12.6903									8.3087			3.9725					
822					13.0584	13.0786	13.1795		13.3107	8.5273			4.0043				3.2686	
826					13.1103	13.1103	13.2413		13.3622	8.5474			4.0066				3.2690	
830	12.8179				13.1836	13.1836	13.2842		13.4150	8.5874			4.0087	4.0255			3.2838	
834					13.2306	13.2306	13.3519		13.4631	8.6186			4.0379				3.2960	
838					13.2764	13.2764	13.4186		13.5405	8.6454			4.0479				3.3033	
840	12.9443									8.4483			4.0401					
842					13.3199	13.3301	13.4728		13.5747	8.6676			4.0663				3.3172	
846					13.3714	13.3919	13.5046		13.6276	8.6940			4.0811				3.3311	
850	13.0953				13.4652	13.4652	13.5892		13.7132	8.7343			4.0732	4.0995			3.3451	
854					13.5077	13.5180	13.6319		13.7664	8.7608			4.1082				3.3547	

† Measurements taken on 18 June 1993.

‡ Measurements taken on 21 June 1993.

§ Measurements taken on 23 June 1993.

Table 18. (cont.) The WFF sphere (two lamps operated simultaneously, both with apertures open, No. 3, No. 5, and No. 6 as indicated) spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{ sr}^{-1}$] measured with the 746/ISIC, the PR714 (small aperture), and the BSIXR on 18, 21, and 23 June 1993; and the SXR on 21 and 23 June 1993 (date and time are in PDT).

λ [nm]	open 746	open BSIXR	open PR714	open SXR	open PR714	open PR714	open SXR	open PR714	open SXR	3 746	3 PR714	3 SXR	5 746	5 PR714	5 SXR	6 PR714	6 SXR
858		1246†	1030†	1205†	13.5741	13.6989	13.8237	8.7914	1221†	1211†	1223†	1239†	4.1201	1258†	1305†	1326†	1328†
860	13.2414		13.5637					8.5989					4.1056			3.3680	
862			13.6042		13.6147	13.7617	13.8877	8.8165						4.1275		3.3696	
866			13.6414		13.6623	13.8196	13.9454	8.8244						4.1270		3.3637	
870	13.3837		13.7293		13.7397	13.8754	14.0110	8.6739					4.1407	4.1417		3.3802	
874			13.8113		13.8217	13.9573	14.0930	8.9095						4.1684		3.4048	
878			13.8746		13.9059	14.0417	14.1565	8.9543						4.1895		3.4222	
880	13.5457							8.7895					4.1741				
882			13.9478		13.9478	14.0827	14.2072	8.9861						4.1957		3.4288	
886			14.0038		13.9935	14.1277	14.2825	9.0039						4.1950		3.4323	
890	13.6586		14.0520		14.0417	14.1961	14.3299	8.8596					4.2065	4.2043		3.4373	
894			14.0653		14.0857	14.2187	14.3517	9.0315						4.2134		3.4411	
898			14.1150		14.1354	14.2780	14.3900	9.0546						4.2182		3.4453	
900	13.7700							8.8984					4.2299				
902			14.1415		14.1415	14.3143	14.4465	9.0644						4.2160		3.4403	
906			14.1517		14.1619	14.3242	14.4662	9.0612						4.2181		3.4390	
910	13.8795		14.1746		14.1847	14.3467	14.4682	8.9426					4.2464	4.2210		3.4424	
914			14.2116		14.2116	14.3836	14.5152	9.0816						4.2189		3.4436	
918			14.2255		14.2356	14.3977	14.5598	9.0865						4.2221		3.4479	
920	13.9880							8.9800					4.2724				
922			14.2733		14.2733	14.4254	14.5774	9.0921						4.2333		3.4548	
926			14.3163		14.3061	14.4894	14.6116	9.1111						4.2379		3.4589	
930	14.0123		14.3604		14.3706	14.5651	14.6982	8.9981					4.2724	4.2426		3.4606	
934			14.4441		14.4441	14.6502	14.7944	9.1795						4.2652		3.4802	
938			14.5294		14.5191	14.7054	14.8813	9.2144						4.2854		3.4906	
940	14.1397							9.0555					4.3001				
942			14.5421		14.5421	14.7596	14.8942	9.2369						4.2891		3.4874	
946			14.6087		14.6087	14.8060	14.9410	9.2667						4.2964		3.5011	
954			14.6956		14.6852	14.8938	15.0711	9.2846						4.3138		3.5107	
958			14.7182		14.7287	14.9370	15.0932	9.3226						4.3217		3.5280	
960	14.4162							9.2152					4.3702				

† Measurements taken on 18 June 1993.

‡ Measurements taken on 21 June 1993.

§ Measurements taken on 23 June 1993.

λ [nm]	open 746	open BSIXR	open PR714	open SXR	open PR714	open PR714	open SXR	open PR714	open SXR	3 746	3 PR714	3 SXR	5 746	5 PR714	5 SXR	6 PR714	6 SXR
962			14.7491	1205†	1220†	14.7908	14.9573	15.1238			9.3522	1239†		1258†	1305†	1326†	1328†
966			14.7768		14.7768	14.9849		15.1514			9.3520			4.3352		3.5358	
970	14.5259		14.8036		14.8141	15.0434		15.1894		9.2665	9.3555		4.3971	4.3306		3.5372	
974			14.8393		14.8290	15.0472		15.1823			9.3536			4.3229		3.5332	
978			14.9040		14.9249	15.1125		15.2480			9.3906			4.3430		3.5384	
980	14.5885									9.2937			4.4062				
982			14.9803		14.9908	15.1796		15.3370			9.4298			4.3671		3.5615	
986			14.9762		14.9972	15.2172		15.3535			9.4322			4.3682		3.5643	
990	14.6551		14.9718		14.9928	15.2439		15.3589		9.3295	9.4361		4.4237	4.3629		3.5656	
994			14.9906		15.0116	15.2635		15.4000			9.4615			4.3702		3.5713	
998			15.0659		15.0869	15.3179		15.4439			9.4690			4.3728		3.5696	
1000	14.6919									9.3381			4.4242				
1002			15.0682		15.0682	15.3090		15.4661			9.4577			4.3739		3.5707	
1006			15.0793		15.1108	15.3207		15.4991			9.4789			4.3716		3.5584	
1010			15.0748		15.1270	15.3358		15.5133			9.4771			4.3658		3.5515	
1014			15.0907		15.0804	15.3183		15.5045			9.4620			4.3628		3.5436	
1018			15.1430		15.0709	15.3183		15.4729			9.4961			4.3677		3.5615	
1022			15.1418		15.1418	15.3795		15.5449			9.4820			4.3813		3.5741	
1026			15.1553		15.1655	15.3610		15.5051			9.4934			4.3892		3.5733	
1030			15.2065		15.1962	15.3609		15.5256			9.4997			4.3879		3.5818	
1034			15.1012		15.1115	15.3596		15.5456			9.4897			4.3763		3.5722	
1038			15.0957		15.0750	15.3647		15.5096			9.5541			4.3776		3.5706	
1042			15.0449		15.0552	15.2412		15.4788			9.4361			4.3647		3.5515	
1046			15.0997		15.0483	15.2025		15.4081			9.3898			4.3284		3.5287	
1050			15.0589		14.9557	15.2445		15.3477			9.3097			4.2969		3.5285	
1054			15.0359		15.0046	15.3491		15.3700			9.3191			4.3228		3.5313	
1058			14.9557		15.0396	15.2390		15.3020			9.3103			4.3062		3.5411	
1062			14.7931		14.8880	15.3308		15.3519			9.3018			4.3430		3.5069	
1066			14.8019		15.0310	15.2185		15.2498			9.3613			4.3208		3.4916	
1070			14.7442		14.7752	15.0540		15.1882			9.3060			4.2756		3.4981	

§ Measurements taken on 23 June 1993.

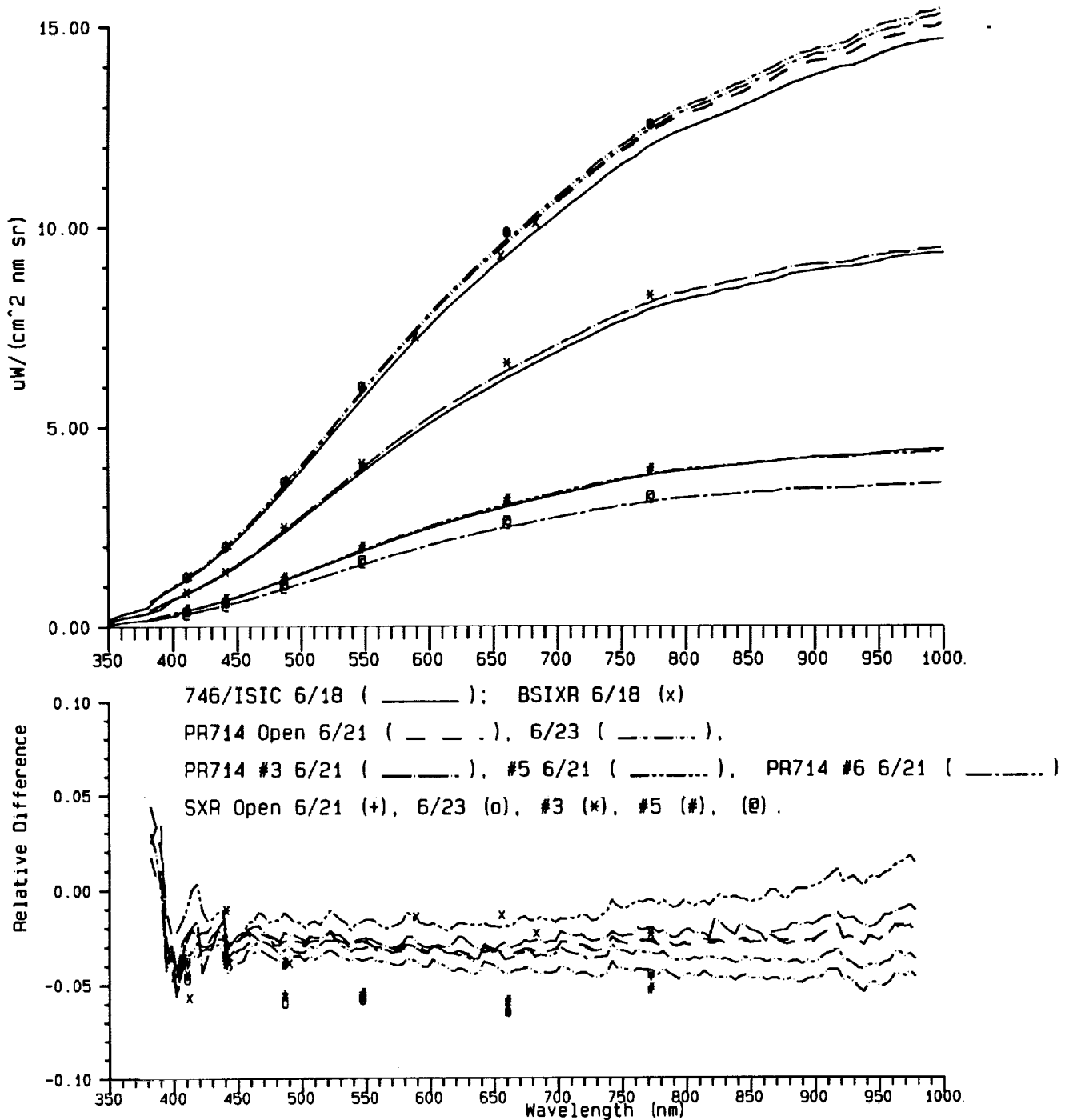


Fig. 29. Spectral radiance of the WFF sphere, measured with the 746/ISIC (18 June; with *open*, *No. 3*, and *No. 5* apertures, in order of decreasing magnitude), the BSIXR (18 June; *open*), the PR714 and SXR (21 June; with *open*, *No. 3*, *No. 5*, and *No. 6* apertures in order of decreasing magnitude; 23 June; *open* aperture) [see key above]. The top panel illustrates spectral radiance ($\mu W cm^{-2} nm^{-1} sr^{-1}$) of the sphere, and the bottom panel illustrates the relative differences between the PR714, SXR, and 746/ISIC radiances at each aperture.

this magnitude from day to day, or whether some or all of the spheres vary either spatially or temporally.

The extreme day-to-day variability of the CHORS sphere may result (at least in part) from inadequate seasoning of the new 275 W lamps. The lamps used in the CHORS sphere demonstrate line structure, especially at wavelengths above 700 nm, but to a lesser extent in the visible range as well. Although the SIRREX-2 measurements suggest that the sphere can be used in this configuration to calibrate visible radiometer channels (assuming a plaque or sphere transfer is made from a lamp irradiance source), it is advisable to further modify the lamp housings to accept seasoned lamps of a series known to be relatively free from line structure. This upgrade will be done in early 1994.

The largest same-day differences (greater than 5%, Fig. 28) were in the PR714, 746/ISIC, and SXR measurements of the UCSB sphere with external illumination. It is very difficult to baffle all stray light between the lamp and the spheres, and these discrepancies may result from residual stray light contamination of the 746/ISIC irradiance measurements of the very low output from this sphere. The PR714, SXR, and other narrow field-of-view radiometers, should be much less susceptible to stray light, and the direction of the difference is compatible with this speculation. A third possible explanation for this large disagreement is that the radiance distribution in this sphere may be extremely inhomogeneous.

OCR100 measurements of several of the spheres were made by S. McLean of Satlantic. These measurements were compared with the PR714, 746/ISIC, and SXR and found similar magnitudes of between instrument discrepancies, with no suggestion of particularly better agreement with any one of the other instruments. In short, these data exhibit the same characteristics as those already described and do not lead to any modifications in the results or conclusions. Therefore, they are not included specifically in the figures or discussions for individual spheres.

In summary, the SIRREX-2 radiance scale transfer measurements for integrating spheres achieved only a 5–7% degree of internal consistency. In terms of uncertainty, this represents no improvement over the results of SIRREX-1. Nevertheless, the more extensive sequence of test experiments carried out during SIRREX-2 gives both a more conclusive estimate of the uncertainties in the sources and procedures in use today, and a better understanding of the full scope of possible sphere and radiometer characteristics which may contribute to the observed inconsistencies.

Temporal variations (either day to day, or on shorter time scales following lamp warm up) in sphere illumination could possibly have contributed to some of the observed discrepancies. The new lamps in the CHORS sphere may be especially suspect in this regard. Transfers to the GSFC sphere, based on the irradiance scale of FEL lamp F269, with the 746/ISIC on 15–19 June 1993 indicate that this

sphere is temporally stable within 1% (at least on a day-to-day basis); F269 and the 746/ISIC were not used to check the GSFC sphere on subsequent days when measurements with the PR714, SXR, and OCR100 indicate variability in its radiance scale of approximately 3%.

Spatial, or angular, variability in radiance in the exit port could also account for many aspects of the variability measured with the PR714 and other narrow field-of-view radiometers. Subsequent to SIRREX-2, the spatial uniformity of the GSFC sphere was determined (Appendix C). These results, which show up to a 4% variability, significantly impact the SIRREX-2 measurements, apparently limiting the uncertainty of any calibration made by the GSFC sphere, using a calibrated transfer radiometer, to about 4%. Such inhomogeneities may result from some combination of either incomplete diffusion of lamp illumination in the sphere, or spatial variability of reflectance in the wall coating material. Each time a narrow field-of-view radiometer is set up to view the sphere, it may see a slightly different sub-area of the exit port, or possibly view it from a slightly different angle. These phenomena would not explain short-term variability in repeated measurements for a fixed instrument setup, but could explain variations between setups (including instrument placement and alignment, focus distance settings, and aperture settings). The extreme same-day, between instrument results for the UCSB sphere may be especially suspect in this regard.

Sensitivity to stray light incident from angles outside a radiometer's nominal field-of-view also leads to errors and variations. With the 746/ISIC irradiance measurement, un baffled stray light from angles beyond the exit port of the source sphere clearly leads to a positive radiance error; the illumination configuration of the UCSB sphere makes it especially difficult to completely eliminate this source of error. With the narrow field-of-view radiometers (PR714, SXR, OCR100, and BSIXR), out-of-field sensitivity creates a large aperture which may not be filled by a sphere's exit port area, and the degree of underfilling will be sensitive to exact instrument placement, focus, etc. This could lead to errors and variability between setups which, on the basis of the SIRREX-2 measurements alone, cannot be distinguished from radiance inhomogeneity in the sphere. For example, NIST characterized the SXR following SIRREX-2 and found significant stray light sensitivity to angles well beyond the instrument's designed 2.5° field-of-view. Although the SIRREX-2 data were corrected accordingly, this size of source effect introduces uncertainties of up to 2% in some cases. (The SXR has since been modified to eliminate this stray light sensitivity.) Adequate characterization data are not available for each of the other small field-of-view instruments, and particularly the PR714, to rule out this possible source of variability in their data as well.

Temporal variations in the responsivity of a transfer radiometer is also a possible explanation for observed day-to-day and shorter interval variability in sphere radiance. The

Table 19. The NOAA Optronics 420M sphere spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{ sr}^{-1}$] measured with the SXR (small aperture) and the PR714 (large aperture; corrected to the scale of the GSFC sphere) on 22 and 24 June 1993 (date and time in PDT). Column indices correspond to the 420M settings: (1) D40,S3,W6 and (2) D100,S3,W5.

λ [nm]	(1) PR714 1307†	(1) SXR 1311†	(1) PR714 1318†	(2) PR714 1336†	(1) SXR 0922	(1) PR714 0930
382	0.0604		0.0597	0.0139		0.0595
386	0.0690		0.0689	0.0155		0.0698
390	0.0781		0.0765	0.0171		0.0769
394	0.0847		0.0850	0.0194		0.0853
398	0.0926		0.0919	0.0211		0.0927
402	0.1007		0.0996	0.0227		0.1002
406	0.1088		0.1092	0.0246		0.1077
410	0.1170		0.1175	0.0264		0.1174
411		0.1241			0.1221	
414	0.1254		0.1259	0.0285		0.1260
418	0.1353		0.1355	0.0306		0.1352
422	0.1452		0.1445	0.0327		0.1445
426	0.1559		0.1555	0.0352		0.1551
430	0.1652		0.1654	0.0377		0.1650
434	0.1756		0.1759	0.0398		0.1762
438	0.1866		0.1864	0.0422		0.1867
441		0.2036			0.1974	
442	0.1986		0.1991	0.0451		0.1988
446	0.2106		0.2104	0.0475		0.2100
450	0.2219		0.2208	0.0500		0.2207
454	0.2348		0.2342	0.0530		0.2336
458	0.2459		0.2457	0.0555		0.2458
462	0.2576		0.2574	0.0582		0.2578
466	0.2706		0.2707	0.0612		0.2700
470	0.2838		0.2844	0.0642		0.2840
474	0.2984		0.2984	0.0674		0.2978
478	0.3135		0.3138	0.0710		0.3134
482	0.3271		0.3270	0.0740		0.3275
486	0.3397		0.3400	0.0770		0.3399
487		0.3585			0.3397	
490	0.3546		0.3543	0.0803		0.3540
494	0.3701		0.3702	0.0837		0.3696
498	0.3851		0.3866	0.0874		0.3862
502	0.4014		0.4014	0.0910		0.4012
506	0.4149		0.4138	0.0940		0.4144
510	0.4302		0.4304	0.0974		0.4301
514	0.4459		0.4460	0.1011		0.4454
518	0.4601		0.4598	0.1041		0.4598
522	0.4778		0.4770	0.1079		0.4769
526	0.4936		0.4948	0.1120		0.4939
530	0.5090		0.5096	0.1154		0.5095
534	0.5256		0.5254	0.1190		0.5251
538	0.5432		0.5431	0.1231		0.5426
542	0.5583		0.5579	0.1265		0.5583
546	0.5739		0.5749	0.1299		0.5733

† Measurements taken on 22 June 1993; all other measurements were taken on 24 June 1993.

Table 19. (cont.) The NOAA Optronics 420M sphere spectral radiance [$\mu\text{W cm}^{-2}\text{nm}^{-1}\text{sr}^{-1}$] measured with the SXR (small aperture) and the PR714 (large aperture; corrected to the scale of the GSFC sphere) on 22 and 24 June 1993 (date and time in PDT). Column indices correspond to the 420M settings: (1) D40,S3,W6 and (2) D100,S3,W5.

λ [nm]	(1) PR714 1307†	(1) SXR 1311†	(1) PR714 1318†	(2) PR714 1336†	(1) SXR 0922	(1) PR714 0930
547		0.6052			0.5514	
550	0.5907		0.5916	0.1339		0.5908
554	0.6058		0.6072	0.1371		0.6066
558	0.6233		0.6235	0.1411		0.6235
562	0.6407		0.6412	0.1452		0.6397
566	0.6581		0.6577	0.1491		0.6565
570	0.6743		0.6735	0.1529		0.6734
574	0.6912		0.6919	0.1568		0.6900
578	0.7050		0.7063	0.1600		0.7049
582	0.7182		0.7196	0.1628		0.7187
586	0.7356		0.7359	0.1667		0.7351
590	0.7536		0.7537	0.1708		0.7536
594	0.7711		0.7708	0.1746		0.7707
598	0.7887		0.7889	0.1790		0.7886
602	0.8060		0.8060	0.1829		0.8057
606	0.8186		0.8193	0.1856		0.8185
610	0.8329		0.8334	0.1889		0.8327
614	0.8485		0.8480	0.1922		0.8472
618	0.8593		0.8601	0.1946		0.8596
622	0.8758		0.8760	0.1983		0.8749
626	0.8928		0.8930	0.2022		0.8917
630	0.9113		0.9096	0.2065		0.9098
634	0.9277		0.9265	0.2102		0.9264
638	0.9397		0.9409	0.2128		0.9395
642	0.9537		0.9531	0.2159		0.9534
646	0.9661		0.9667	0.2189		0.9652
650	0.9751		0.9751	0.2212		0.9751
654	0.9886		0.9877	0.2243		0.9877
658	1.0020		1.0011	0.2273		1.0011
661		1.0670			0.9711	
662	1.0200		1.0191	0.2314		1.0181
666	1.0346		1.0356	0.2348		1.0346
670	1.0481		1.0501	0.2377		1.0501
674	1.0651		1.0661	0.2418		1.0661
678	1.0779		1.0789	0.2448		1.0789
682	1.0872		1.0872	0.2464		1.0872
686	1.0966		1.0957	0.2484		1.0957
690	1.1074		1.1064	0.2506		1.1045
694	1.1140		1.1150	0.2524		1.1121
698	1.1260		1.1260	0.2555		1.1240
702	1.1403		1.1393	0.2587		1.1373
706	1.1536		1.1546	0.2619		1.1526
710	1.1714		1.1734	0.2662		1.1714
714	1.1897		1.1908	0.2700		1.1877
718	1.2034		1.2034	0.2730		1.2024

† Measurements taken on 22 June 1993; all other measurements were taken on 24 June 1993.

Table 19. (cont.) The NOAA Optronics 420M sphere spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{ sr}^{-1}$] measured with the SXR (small aperture) and the PR714 (large aperture; corrected to the scale of the GSFC sphere) on 22 and 24 June 1993 (date and time in PDT). Column indices correspond to the 420M settings: (1) D40,S3,W6 and (2) D100,S3,W5.

λ [nm]	(1) PR714 1307†	(1) SXR 1311†	(1) PR714 1318†	(2) PR714 1336†	(1) SXR 0922	(1) PR714 0930
722	1.2158		1.2178	0.2766		1.2158
726	1.2287		1.2297	0.2795		1.2277
730	1.2342		1.2351	0.2805		1.2322
734	1.2438		1.2429	0.2833		1.2429
738	1.2507		1.2517	0.2854		1.2498
742	1.2493		1.2522	0.2851		1.2484
746	1.2516		1.2525	0.2855		1.2506
750	1.2651		1.2670	0.2890		1.2641
754	1.2896		1.2906	0.2944		1.2877
758	1.3121		1.3121	0.2996		1.3111
762	1.3179		1.3179	0.3010		1.3139
766	1.3252		1.3262	0.3029		1.3233
770	1.3354		1.3383	0.3058		1.3354
772		1.4006			1.3613	
774	1.3473		1.3493	0.3086		1.3463
778	1.3553		1.3563	0.3103		1.3534
782	1.3574		1.3594	0.3110		1.3564
786	1.3639		1.3639	0.3127		1.3620
790	1.3704		1.3734	0.3143		1.3684
794	1.3719		1.3739	0.3145		1.3699
798	1.3753		1.3763	0.3150		1.3733
802	1.3835		1.3845	0.3175		1.3815
806	1.3911		1.3921	0.3194		1.3882
810	1.3966		1.3976	0.3205		1.3937
814	1.4018		1.4028	0.3215		1.3998
818	1.4106		1.4116	0.3239		1.4087
822	1.4130		1.4159	0.3245		1.4110
826	1.4148		1.4167	0.3244		1.4128
830	1.4236		1.4265	0.3272		1.4207
834	1.4288		1.4317	0.3280		1.4268
838	1.4295		1.4314	0.3279		1.4285
842	1.4338		1.4368	0.3292		1.4329
846	1.4380		1.4410	0.3311		1.4370
850	1.4413		1.4453	0.3321		1.4413
854	1.4436		1.4456	0.3324		1.4416
858	1.4467		1.4497	0.3332		1.4446
862	1.4485		1.4505	0.3333		1.4475
866	1.4480		1.4520	0.3334		1.4480
870	1.4542		1.4583	0.3349		1.4532
874	1.4622		1.4653	0.3374		1.4622
878	1.4662		1.4692	0.3382		1.4662
882	1.4696		1.4726	0.3387		1.4686
886	1.4717		1.4747	0.3392		1.4707
890	1.4742		1.4792	0.3401		1.4762
894	1.4844		1.4904	0.3423		1.4854

† Measurements taken on 22 June 1993; all other measurements were taken on 24 June 1993.

Table 19. (cont.) The NOAA Optronics 420M sphere spectral radiance [$\mu\text{W cm}^{-2}\text{ nm}^{-1}\text{sr}^{-1}$] measured with the SXR (small aperture) and the PR714 (large aperture; corrected to the scale of the GSFC sphere) on 22 and 24 June 1993 (date and time in PDT). Column indices correspond to the 420M settings: (1) D40,S3,W6 and (2) D100,S3,W5.

λ [nm]	(1) PR714 1307†	(1) SXR 1311†	(1) PR714 1318†	(2) PR714 1336†	(1) SXR 0922	(1) PR714 0930
898	1.4902		1.4932	0.3437		1.4912
902	1.4793		1.4833	0.3413		1.4803
906	1.4642		1.4672	0.3380		1.4623
910	1.4407		1.4446	0.3325		1.4398
914	1.4319		1.4357	0.3301		1.4328
918	1.4338		1.4386	0.3311		1.4357
922	1.4440		1.4489	0.3334		1.4440
926	1.4549		1.4569	0.3349		1.4529
930	1.4591		1.4621	0.3365		1.4581
934	1.4603		1.4623	0.3363		1.4563
938	1.4587		1.4617	0.3361		1.4547
942	1.4565		1.4605	0.3357		1.4575
946	1.4550		1.4590	0.3367		1.4560
950	1.4544		1.4564	0.3361		1.4554
954	1.4495		1.4505	0.3343		1.4475
958	1.4504		1.4544	0.3349		1.4504
962	1.4500		1.4521	0.3353		1.4480
966	1.4415		1.4435	0.3333		1.4405
970	1.4407		1.4447	0.3330		1.4407
974	1.4382		1.4463	0.3330		1.4392
978	1.4444		1.4475	0.3334		1.4434
982	1.4473		1.4503	0.3335		1.4452
986	1.4452		1.4523	0.3339		1.4472
990	1.4418		1.4509	0.3344		1.4479
994	1.4447		1.4467	0.3349		1.4478
998	1.4435		1.4476	0.3350		1.4466
1002	1.4423		1.4443	0.3342		1.4413
1006	1.4417		1.4499	0.3339		1.4478
1010	1.4412		1.4432	0.3334		1.4422
1014	1.4418		1.4418	0.3325		1.4337
1018	1.4284		1.4354	0.3300		1.4284
1022	1.4267		1.4367	0.3304		1.4277
1026	1.4239		1.4309	0.3309		1.4239
1030	1.4192		1.4192	0.3280		1.4182
1034	1.4139		1.4149	0.3261		1.4139
1038	1.4214		1.4164	0.3274		1.4204
1042	1.4120		1.4150	0.3269		1.4110
1046	1.3927		1.4075	0.3212		1.3936
1050	1.3849		1.4118	0.3231		1.4058
1054	1.3998		1.4008	0.3248		1.4149
1058	1.4152		1.3978	0.3232		1.3978
1062	1.3818		1.3951	0.3191		1.3889
1066	1.3982		1.4043	0.3224		1.4063
1070	1.3751		1.3893	0.3180		1.3781

† Measurements taken on 22 June 1993; all other measurements were taken on 24 June 1993.

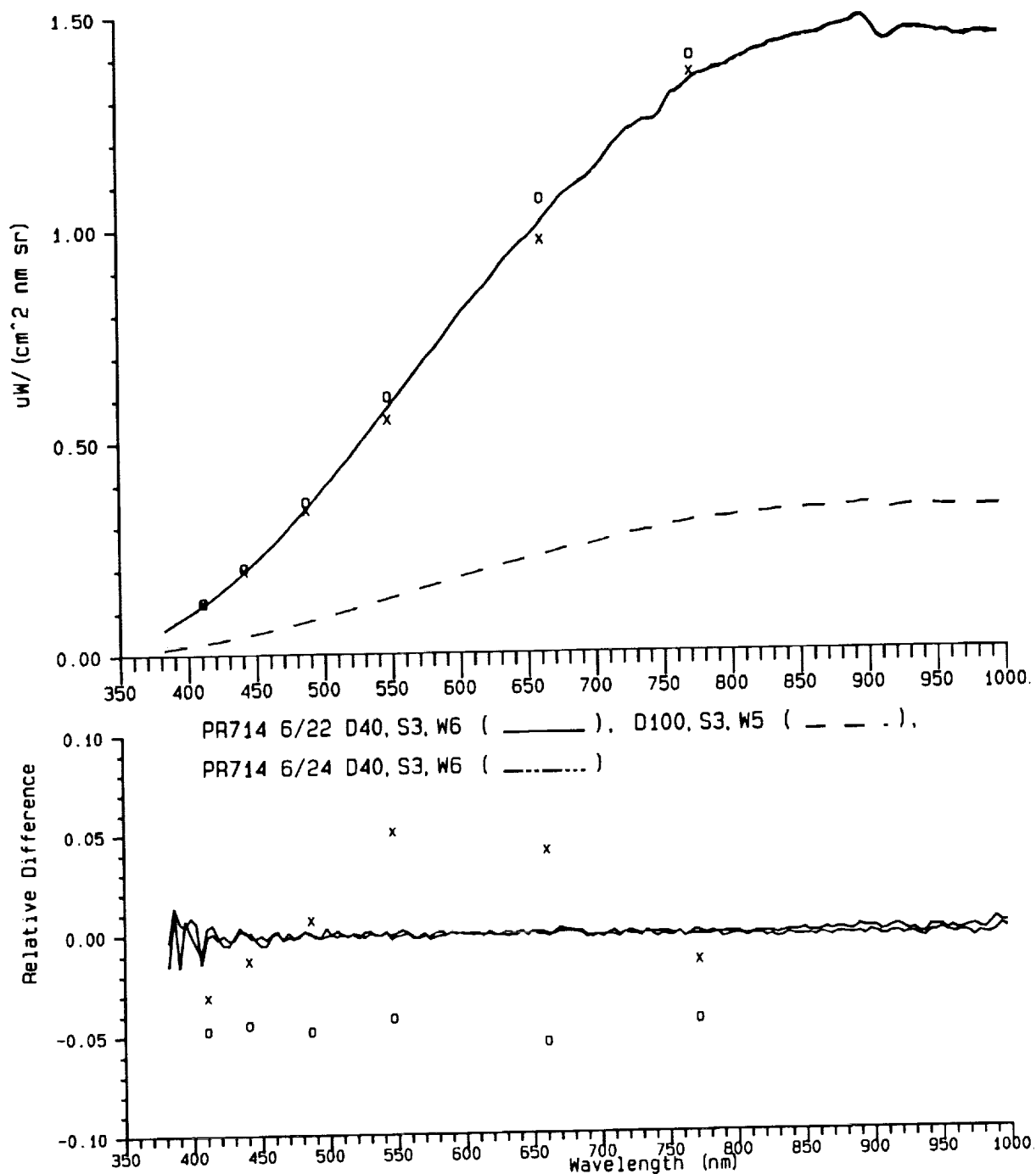


Fig. 30. Spectral radiance of the NOAA Optronics 420M sphere, measured with the PR714 on 22 June (D100,S3,W5) and with the SXR on 22 June (o) and 24 June (x) (D40,S3,W6). The top panel illustrates spectral radiance ($\mu W cm^{-2} nm^{-1} sr^{-1}$), and the bottom panel illustrates the differences between the D40,S3,W6 radiance spectra measured on 22 June, relative to that measured on 24 June.

746/ISIC responsivity was independently determined with lamp F269 for each measurement setup, so it can be excluded in this regard. However, the PR714 was calibrated using the GSFC sphere radiance scale (confirmed with the 746/ISIC and lamp F269) on 19 June 1993, and this responsivity scale was applied to all measurements with that instrument throughout SIRREX-2. Temporal drift in the spectral responsivity of the PR714 offers a very plausible explanation for many of the measured differences.

Taken together, these results and possible explanations can only be resolved if all SIRREX spheres are fully characterized for spatial and angular homogeneity and temporal stability, and if all SIRREX transfer radiometers are fully characterized for angular field-of-view and geometric stray light rejection, out-of-band stray light rejection, and temporal stability of spectral responsivity. This work should form a central focus for the SIRREX activity in 1994, with the ultimate objective of obtaining an uncertainty of 1% in spectral radiance scale realizations. An uncertainty of 1% for all surface measurements is the goal for verifying an uncertainty of 5% in the SeaWiFS measurements of normalized water-leaving radiance.

4. PLAQUE REFLECTANCE

At the majority of the SIRREX laboratories, reflectance plaques are used to convert known spectral irradiance from a lamp to calculated spectral radiance, for fixed angles of illumination and reflection when the plaque is viewed by a narrow field-of-view spectral radiometer. In some cases, this composite FEL lamp and plaque source of spectral radiance is used directly to calibrate a field radiometer. In other cases, it is used to calibrate a stable transfer radiometer, which may then be used to transfer the radiance scale to an integrating sphere, which can provide a larger and more uniform source of diffuse radiance (Section 3.0 above).

At NIST, GSFC, and UA, small pressed Halon plaques are made as primary standards of known reflectance. At all SIRREX laboratories, however, plaques used in routine laboratory and field measurements are fabricated from Spectralon, a sintered version of Halon, available commercially from Labsphere, Inc. For comparison at SIRREX-2, large Spectralon plaques were contributed by CHORS, BSI, UCSB, and Satlantic, and small plaques were contributed by BSI, UCSB, and NOAA (see Appendix A for plaque specifications).

4.1 Methods

FEL lamp 91349B (with the lamp masked by a circular baffle; Table 2) was aligned carefully at 150.0 cm normal to one of the Spectralon plaques, which was mounted in a kinematic holder at the end of the CHORS optical bar. The PR714 spectroradiometer (large aperture setting) was aligned to view the center of the plaque at 45.0° from normal at an approximate distance of 1.5 m.

Lamp 91349B was warmed up for 20 minutes prior to beginning the measurements. Spectral radiance reflected at 45° was measured with the PR714, based on the calibration transferred from the GSFC sphere on 19 June 1993 (Tables 6 and 7). The other plaques were then substituted sequentially into the kinematic mount holder until the spectral reflectance of all seven plaques were measured.

4.2 Results

Spectral (0°, 45°) bidirectional reflectances calculated from the above measurements of the eight plaques are listed in Table 20 and illustrated in Fig. 31. Standard deviations, σ , are less than 1% at all wavelengths, and are less than 0.5% at wavelengths greater than 438 nm.

4.3 Discussion and Conclusions

The apparent plaque reflectance spectra illustrated in Fig. 31 all show spectral features which are common to the PR714 spectral responsivity calibration function, as determined from the GSFC sphere on 19 June 1993 (Fig. 18). In this regard, note the especially strong similarity in the oscillatory features near 400 nm and near 725 nm in Figs. 18 and 31. This feature suggests that the spectral features in Fig. 31 are an artifact of the responsivity assumed for the PR714, and further leads to the suspicion that these results may also be contaminated by drift in the responsivity of the instrument between its calibration on 19 June and these measurements on 25 June. If the radiance measurements were accurate, the occurrence of reflectances greater than 1 could be explained by a specular component in (0°, 45°) plaque reflectance. Given the above noted uncertainty regarding the PR714, however, it must be concluded that these particular measurements of apparent (0°, 45°) BRDF are not sufficiently reliable for use in irradiance to radiance transfers from FEL lamps.

The approximate 1% envelope in apparent reflectance functions for several different Spectralon plaques does support the assumption that these plaques are effectively interchangeable, once valid BRDF measurements are realized.

5. VOLTMETERS AND SHUNTS

Voltmeters and precision shunt resistors were intercompared on 24 June 1993. Voltmeters, manufacturers, models, and owners are:

Owner	Manufacturer	Model S/N
GSFC	Fluke 8842A	561078
UA	HP3457	2538A02159
Satlantic	HP34401A	3146A09840
CHORS	HP34401A	3146A08065
NOAA	HP34401A	3146A14453

Table 20. The spectral reflectance ($\pi \times L/E$) (0° , 45°) for several Spectralon plaques. The owner and size of each square plaque is listed at the top of each column. Note that the large CHORS plaque was run twice—once with the other large plaques, and then again with the small plaques for cross reference. The average of columns 1–8 is listed as \bar{F} .

λ [nm]	Large Plaques					Small Plaques			\bar{F}	σ
	BSI	CHORS	Satlantic	UCSB	CHORS†	BSI	NOAA	UCSB		
382	0.9477	0.9356	0.9315	0.9438	0.9263	0.9447	0.9450	0.9320	0.9383	0.0079
386	1.0023	0.9905	0.9767	0.9885	0.9841	0.9994	1.0014	0.9901	0.9916	0.0090
390	1.0070	0.9959	0.9908	1.0095	0.9984	1.0037	1.0111	1.0072	1.0030	0.0072
394	1.0379	1.0256	1.0204	1.0426	1.0271	1.0345	1.0383	1.0334	1.0325	0.0075
398	1.0370	1.0193	1.0117	1.0327	1.0184	1.0337	1.0352	1.0224	1.0263	0.0095
402	1.0197	1.0053	1.0016	1.0142	1.0019	1.0152	1.0182	1.0103	1.0108	0.0072
406	1.0109	1.0009	0.9948	1.0069	1.0003	1.0070	1.0076	1.0015	1.0037	0.0052
410	1.0064	0.9948	0.9858	1.0024	0.9952	1.0063	1.0032	0.9985	0.9991	0.0070
414	1.0040	0.9891	0.9810	0.9969	0.9896	1.0024	0.9977	0.9945	0.9944	0.0076
418	1.0034	0.9934	0.9853	0.9992	0.9905	1.0008	0.9997	0.9950	0.9959	0.0060
422	1.0045	0.9939	0.9883	1.0006	0.9910	1.0024	1.0005	0.9955	0.9971	0.0058
426	1.0161	1.0059	0.9984	1.0116	1.0022	1.0131	1.0109	1.0059	1.0080	0.0059
430	1.0175	1.0079	1.0013	1.0148	1.0070	1.0149	1.0125	1.0097	1.0107	0.0053
434	1.0189	1.0103	1.0033	1.0159	1.0073	1.0157	1.0145	1.0110	1.0121	0.0051
438	1.0207	1.0138	1.0061	1.0167	1.0119	1.0187	1.0177	1.0148	1.0151	0.0046
442	1.0293	1.0210	1.0155	1.0265	1.0192	1.0284	1.0255	1.0228	1.0235	0.0048
446	1.0274	1.0195	1.0152	1.0257	1.0169	1.0257	1.0239	1.0222	1.0221	0.0044
450	1.0226	1.0143	1.0101	1.0193	1.0109	1.0210	1.0167	1.0167	1.0164	0.0045
454	1.0248	1.0168	1.0121	1.0224	1.0144	1.0224	1.0192	1.0192	1.0189	0.0044
458	1.0192	1.0124	1.0079	1.0177	1.0102	1.0155	1.0147	1.0132	1.0138	0.0038
462	1.0139	1.0075	1.0039	1.0125	1.0054	1.0117	1.0096	1.0096	1.0093	0.0035
466	1.0142	1.0074	1.0047	1.0135	1.0054	1.0128	1.0108	1.0094	1.0098	0.0037
470	1.0166	1.0114	1.0075	1.0153	1.0075	1.0140	1.0127	1.0127	1.0122	0.0033
474	1.0201	1.0158	1.0119	1.0189	1.0126	1.0182	1.0170	1.0164	1.0164	0.0029
478	1.0260	1.0211	1.0180	1.0248	1.0186	1.0242	1.0217	1.0229	1.0222	0.0029
482	1.0252	1.0187	1.0163	1.0234	1.0163	1.0228	1.0205	1.0210	1.0205	0.0033
486	1.0207	1.0158	1.0130	1.0213	1.0136	1.0185	1.0169	1.0174	1.0171	0.0030
490	1.0215	1.0168	1.0152	1.0210	1.0152	1.0204	1.0173	1.0184	1.0182	0.0025
494	1.0256	1.0200	1.0185	1.0251	1.0185	1.0231	1.0205	1.0221	1.0217	0.0028
498	1.0277	1.0227	1.0213	1.0287	1.0213	1.0262	1.0237	1.0257	1.0247	0.0029
502	1.0283	1.0240	1.0216	1.0292	1.0225	1.0268	1.0249	1.0254	1.0253	0.0027
506	1.0232	1.0204	1.0177	1.0242	1.0181	1.0223	1.0195	1.0209	1.0208	0.0024
510	1.0221	1.0194	1.0172	1.0240	1.0172	1.0208	1.0194	1.0213	1.0202	0.0023
514	1.0241	1.0211	1.0189	1.0254	1.0189	1.0219	1.0202	1.0223	1.0216	0.0023
518	1.0206	1.0168	1.0164	1.0218	1.0152	1.0181	1.0164	1.0185	1.0180	0.0023
522	1.0237	1.0205	1.0189	1.0249	1.0193	1.0221	1.0201	1.0221	1.0215	0.0021
526	1.0260	1.0233	1.0217	1.0288	1.0217	1.0249	1.0229	1.0257	1.0244	0.0025
530	1.0243	1.0216	1.0205	1.0265	1.0197	1.0231	1.0212	1.0239	1.0226	0.0023
534	1.0237	1.0219	1.0207	1.0263	1.0200	1.0230	1.0207	1.0245	1.0226	0.0021
538	1.0263	1.0241	1.0227	1.0292	1.0230	1.0245	1.0223	1.0259	1.0247	0.0024
542	1.0251	1.0226	1.0212	1.0276	1.0219	1.0229	1.0212	1.0237	1.0233	0.0022
546	1.0248	1.0231	1.0210	1.0268	1.0217	1.0234	1.0210	1.0241	1.0232	0.0020
550	1.0261	1.0244	1.0225	1.0284	1.0231	1.0248	1.0228	1.0264	1.0248	0.0021
554	1.0244	1.0232	1.0212	1.0276	1.0212	1.0238	1.0209	1.0244	1.0233	0.0022
558	1.0259	1.0247	1.0234	1.0287	1.0234	1.0247	1.0225	1.0253	1.0248	0.0020
562	1.0272	1.0263	1.0245	1.0303	1.0245	1.0254	1.0239	1.0269	1.0261	0.0020
566	1.0278	1.0271	1.0256	1.0314	1.0253	1.0256	1.0241	1.0278	1.0268	0.0022

† Denotes the CHORS plaque that was run a second time for cross reference with the small plaques.

Table 20. (cont.) Spectral reflectance ($\pi \times L/E$) for several Spectralon plaques. The owner and size of each square plaque is listed at the top of each column. Note that the large CHORS plaque was run twice—once with the other large plaques, and then again with the small plaques for cross reference. The average of columns 1–8 is listed as \bar{F} .

λ [nm]	Large Plaques					Small Plaques			\bar{F}	σ
	BSI	CHORS	Satlantic	UCSB	CHORS†	BSI	NOAA	UCSB		
570	1.0274	1.0265	1.0250	1.0309	1.0262	1.0253	1.0244	1.0271	1.0266	0.0021
574	1.0284	1.0287	1.0258	1.0325	1.0272	1.0269	1.0255	1.0290	1.0280	0.0022
578	1.0248	1.0253	1.0231	1.0290	1.0242	1.0239	1.0222	1.0259	1.0248	0.0021
582	1.0208	1.0211	1.0194	1.0246	1.0192	1.0197	1.0178	1.0211	1.0205	0.0020
586	1.0226	1.0218	1.0204	1.0258	1.0207	1.0207	1.0196	1.0226	1.0218	0.0020
590	1.0249	1.0246	1.0238	1.0285	1.0231	1.0228	1.0207	1.0249	1.0242	0.0022
594	1.0260	1.0268	1.0260	1.0304	1.0250	1.0240	1.0225	1.0266	1.0259	0.0022
598	1.0295	1.0310	1.0295	1.0340	1.0287	1.0280	1.0260	1.0310	1.0297	0.0024
602	1.0311	1.0328	1.0301	1.0358	1.0306	1.0294	1.0276	1.0319	1.0312	0.0024
606	1.0277	1.0291	1.0267	1.0323	1.0267	1.0250	1.0240	1.0284	1.0275	0.0026
610	1.0264	1.0269	1.0260	1.0308	1.0264	1.0250	1.0231	1.0274	1.0265	0.0022
614	1.0244	1.0270	1.0256	1.0299	1.0256	1.0239	1.0222	1.0263	1.0256	0.0023
618	1.0205	1.0222	1.0208	1.0261	1.0215	1.0194	1.0179	1.0222	1.0213	0.0024
622	1.0223	1.0244	1.0226	1.0269	1.0230	1.0205	1.0200	1.0230	1.0228	0.0022
626	1.0258	1.0276	1.0258	1.0301	1.0258	1.0245	1.0227	1.0267	1.0261	0.0022
630	1.0293	1.0315	1.0289	1.0337	1.0298	1.0273	1.0255	1.0300	1.0295	0.0025
634	1.0310	1.0338	1.0314	1.0358	1.0312	1.0292	1.0277	1.0319	1.0315	0.0025
638	1.0284	1.0316	1.0302	1.0336	1.0297	1.0274	1.0255	1.0299	1.0295	0.0025
642	1.0286	1.0311	1.0288	1.0326	1.0297	1.0263	1.0251	1.0301	1.0290	0.0024
646	1.0271	1.0296	1.0273	1.0317	1.0290	1.0250	1.0232	1.0281	1.0276	0.0026
650	1.0218	1.0251	1.0227	1.0276	1.0233	1.0204	1.0182	1.0235	1.0228	0.0029
654	1.0214	1.0241	1.0224	1.0271	1.0208	1.0200	1.0182	1.0224	1.0221	0.0027
658	1.0203	1.0241	1.0223	1.0261	1.0219	1.0195	1.0175	1.0229	1.0218	0.0027
662	1.0255	1.0285	1.0263	1.0306	1.0275	1.0251	1.0225	1.0273	1.0267	0.0025
666	1.0282	1.0316	1.0286	1.0330	1.0304	1.0263	1.0255	1.0294	1.0291	0.0026
670	1.0292	1.0335	1.0307	1.0342	1.0321	1.0282	1.0265	1.0311	1.0307	0.0026
674	1.0342	1.0384	1.0365	1.0394	1.0377	1.0327	1.0312	1.0358	1.0357	0.0028
678	1.0350	1.0386	1.0375	1.0393	1.0373	1.0333	1.0317	1.0360	1.0361	0.0026
682	1.0305	1.0353	1.0344	1.0355	1.0334	1.0294	1.0270	1.0318	1.0322	0.0030
686	1.0267	1.0318	1.0316	1.0314	1.0307	1.0262	1.0233	1.0291	1.0289	0.0031
690	1.0261	1.0317	1.0297	1.0311	1.0302	1.0245	1.0228	1.0279	1.0280	0.0033
694	1.0220	1.0277	1.0258	1.0275	1.0268	1.0206	1.0186	1.0243	1.0242	0.0035
698	1.0222	1.0290	1.0271	1.0280	1.0272	1.0212	1.0199	1.0244	1.0249	0.0034
702	1.0256	1.0321	1.0306	1.0306	1.0306	1.0237	1.0226	1.0274	1.0279	0.0036
706	1.0295	1.0361	1.0340	1.0341	1.0349	1.0279	1.0265	1.0309	1.0317	0.0035
710	1.0359	1.0431	1.0413	1.0409	1.0426	1.0352	1.0332	1.0382	1.0388	0.0037
714	1.0410	1.0488	1.0472	1.0465	1.0480	1.0410	1.0383	1.0437	1.0443	0.0039
718	1.0443	1.0508	1.0503	1.0492	1.0503	1.0423	1.0404	1.0464	1.0467	0.0041
722	1.0484	1.0546	1.0541	1.0532	1.0547	1.0469	1.0446	1.0502	1.0508	0.0039
726	1.0499	1.0568	1.0551	1.0544	1.0570	1.0485	1.0463	1.0520	1.0525	0.0040
730	1.0451	1.0534	1.0510	1.0495	1.0517	1.0442	1.0422	1.0483	1.0482	0.0040
734	1.0463	1.0531	1.0510	1.0503	1.0523	1.0446	1.0430	1.0488	1.0487	0.0037
738	1.0442	1.0507	1.0489	1.0483	1.0496	1.0429	1.0406	1.0471	1.0465	0.0036
742	1.0339	1.0409	1.0390	1.0388	1.0395	1.0328	1.0312	1.0369	1.0366	0.0036
746	1.0280	1.0348	1.0326	1.0324	1.0335	1.0269	1.0249	1.0302	1.0304	0.0035
750	1.0326	1.0379	1.0354	1.0365	1.0365	1.0301	1.0281	1.0335	1.0338	0.0034

† Denotes the CHORS plaque that was run a second time for cross reference with the small plaques.

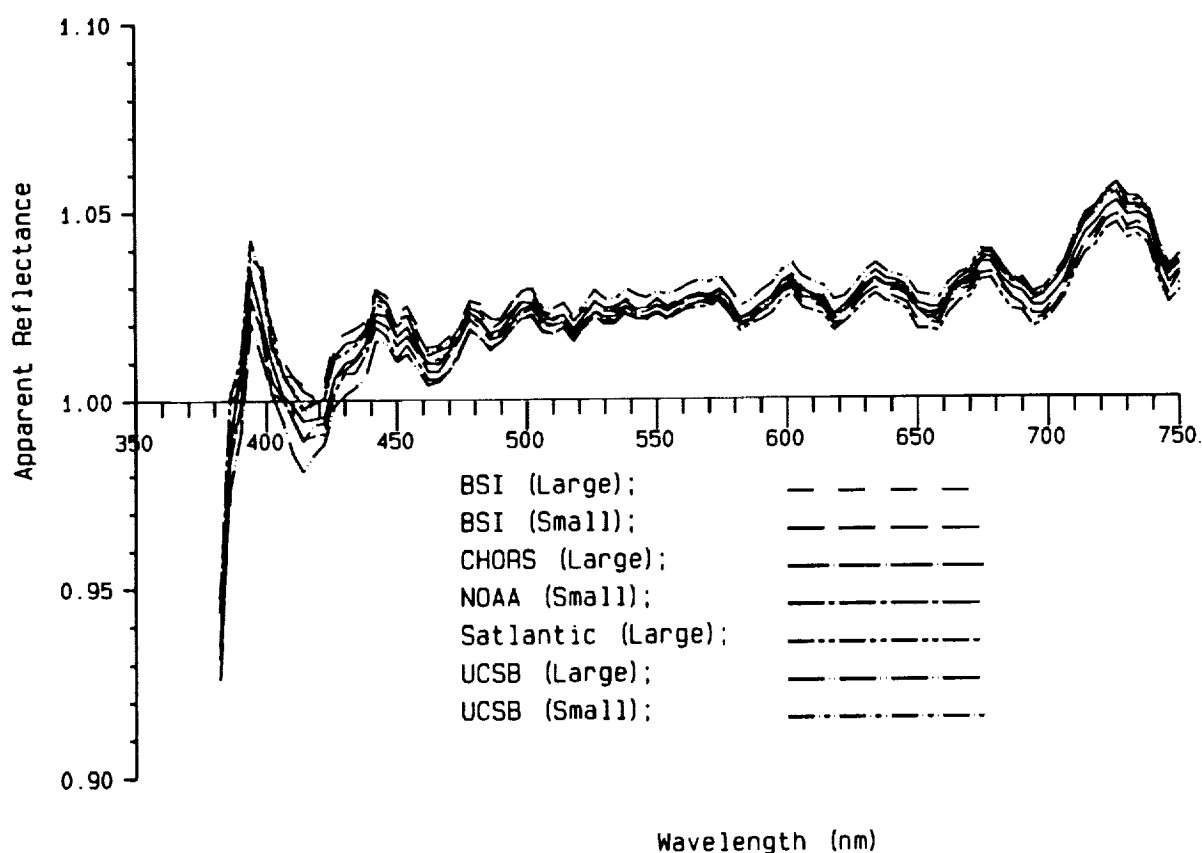


Fig. 31. The spectral reflectance of several Spectralon reflectance plaques belonging to institutions (which are square in shape) are indicated in the curve legend above. These reflectance estimates are calculated from spectral radiance measurements with the PR714, viewing the center of each plaque at 45° incidence while the plaque was illuminated by lamp 91349 (with a circular baffle) at a distance of 150.0 cm normal to the plaque center.

The shunts; their manufacturers, either Leeds & Northrup (L&N) or Weston; the models used; and their respective owners are:

Owner	Manufacturer	Model S/N
GSFC	L&N 4222B	1921670
NOAA	Weston	GS125†
CHORS	Weston	0042211
CHORS	L&N 4385	1630135
Satlantic	L&N C100	1192

† Cat# 0042210

The shunts were connected in series with lamp F269 with the CHORS Optronics 83DS supply at 8.000 A and resulting voltage drops were measured with each voltmeter. All of the HP34401A voltmeters disagreed by 20 μ V (2 mA) and disagreed by 40 μ V (4 mA) when the polarity was reversed to read the negative voltages from the shunts. This difference was attributed to an AC voltage across each shunt, causing a common mode AC which was not rejected by the HP34401 meters, although it was properly rejected by the Fluke 8842A and the HP3457. The total AC output measured across the lamp was found to be 400 mV rms at 120 Hz which indicates some power supply leakage. The shunt currents were measured with the GSFC voltmeter. The voltmeters were compared measuring across the GSFC shunt. Voltages measured across the GSFC shunt by each of the voltmeters are:

Owner	Manufacturer	Voltages [mV]
GSFC	Fluke 8842A	80.001
UA	HP3457	79.997
Satlantic	HP34401A	79.981
CHORS	HP34401A	79.980
NOAA	HP34401A	79.980

Voltage drops measured with the GSFC voltmeter across each shunt are:

Owner	Manufacturer	Voltages [mV]
GSFC	L&N 4222B	80.001
NOAA	Weston	80.007
CHORS	Weston	79.919
CHORS	L&N 4385	80.007
Satlantic	L&N C100	80.006

The CHORS Weston shunt is a previously uncalibrated spare. All other shunt readings match their calibrated values within the specified uncertainty of 0.01%.

To verify that the AC voltage was the source of the voltmeter disagreement, a precision DC reference was assembled using a REF-02 chip, and its output was measured with each voltmeter. The comparisons between all of the voltmeters were within 10 μ V in 5 V (0.0002%). The voltmeters were also compared with F269 using the GSFC Optronics 83DS supply and the GSFC shunt, showing agree-

ment within 8 μ V (0.8 mA). This particular supply showed only 0.8 mV rms of AC across the lamp.

6. SUMMARY AND CONCLUSIONS

This report completes the analyses of the principal data sets acquired during SIRREX-2. The key results are:

1. The NIST (October 1992) spectral irradiance scale of FEL lamp F269 was transferred to FEL lamps used at the participating laboratories with an uncertainty better than 1% (Section 2). It is recommended that the scales of spectral irradiance listed here be used with these lamps for all radiometric calibrations associated with the SeaWiFS program.
 2. The transfer of the spectral radiance scale of the GSFC sphere, as determined using lamp F269, to the integrating sphere sources used by the other laboratories was determined with an overall uncertainty of 5% or larger. Possible sources of these discrepancies include inadequate characterization of temporal stability and homogeneity of radiance in each sphere (see Appendix C), and of geometric stray light and temporal stability of spectral responsivity characteristics of the transfer radiometers used in these measurements.
 3. Spectral (0°, 45°) BRDF estimates for several Spectralon plaques used at various SIRREX laboratories, while internally consistent between plaques, appear to be contaminated by the possibly variable wavelength dependent calibration factors of the PR714 spectroradiometer used for these measurements during SIRREX-2. SIRREX measurements have not yet succeeded in confirming or refining the manufacturer's reflectance calibrations for these plaques.
 4. Shunts and voltmeters available at the SIRREX laboratories for measuring lamp current during radiometric calibrations are within the necessary uncertainty specifications. An exception is that the relatively new model HP34401A multimeters (recently purchased by several laboratories) do not accurately measure shunt voltage supplied by the Optronics 83DS power supply, due to this meter's sensitivity to the AC ripple produced by that supply's current regulation circuitry.
- The principal conclusions and recommendations based on the SIRREX-2 results are:
- a. Lamp sources of spectral irradiance used for calibrations by SIRREX participants are now on a common scale with an uncertainty of less than 1%, which is consistent with the SeaWiFS goals for radiometric accuracy. In the interests of economy, future inter-laboratory checks of these lamps should be carried out at GSFC on a mail exchange basis. The scales of two FEL lamps at each laboratory should be

checked at GSFC on an annual basis. The GSFC lamps should be recalibrated at NIST on a routine basis—at least once every two years.

- b. The approximately 5% uncertainty of intercomparisons between spectral radiance scales of SIRREX integrating sphere sources is not consistent with the SeaWiFS goals for radiometric accuracy. To improve this situation in 1994, the following changes are recommended: 1) all SIRREX spheres must be characterized for temporal stability and homogeneity of radiance, and 2) the geometric stray light, the out-of-band rejection, and the temporal stability (in terms of spectral responsivity characteristics) of transfer radiometers used to intercompare the spheres must be accurately determined. Sources with substandard characteristics, such as the recently measured nonuniformity of the GSFC sphere (Appendix C) must be corrected. The necessary characterizations of the NIST SXR have been completed, but similar characterizations must be performed on a spectroradiometer (to be identified) capable of measuring sphere radiance scales with much finer spectral resolution than can be achieved with the SXR. Sphere and radiometer characterizations must be effected at each individual laboratory prior to intercomparisons during SIRREX-3 sometime in mid-1994.
- c. A second major objective of SIRREX-3 will be to accurately characterize the (0° , 45°) BRDF of Spectralon plaques used by SIRREX participants. Procedures and equipment to be used in this characterization should be defined early in 1994.
- d. In parallel with characterizations of spectral irradiance and radiance sources to be used for SeaWiFS radiometric calibrations, the 1994 SIRREX activities should extend to round-robin instrument calibration exchanges to test the internal consistency of calibrations performed independently at the participating laboratories. Detailed procedures for these blind comparisons remain to be defined, but the essence will be to sequentially calibrate individual radiometers at two or more laboratories within the space of a few weeks, and to then compare the results to determine the uncertainty of radiometric calibrations performed throughout the SIRREX community.
- e. Detailed analysis of the measurement uncertainties associated with all of the procedures described here must be completed.

APPENDICES

- A. Instruments calibrated at SIRREX-2
- B. Attendees to SIRREX-2
- C. Uniformity of the GSFC Sphere

Appendix A

Instruments calibrated at SIRREX-2

Table A-1 (next page) lists the pertinent information regarding the spheres and plaques which were calibrated at SIRREX-2.

Appendix B

Attendees to SIRREX-2

The attendees to SIRREX-2 are presented alphabetically.

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Table A-1. Organizations who participated in the June 1993 SIRREX and their intercalibration and radiometric sources.

Organization	Contact	Lamps	Sphere	Plaque†	Radiometer
BSI	R. Booth	F310	50.8 cm (20 in)	43.2 cm (17 in) [Large]	BSIXR
	G. Adelman	F321		25.4 cm (10 in) [Small]	
		91357			
CHORS	J. Mueller	90572	102 cm (40 in)	43.2 cm (17 in) [Large]	
	R. Austin	91348			
	C. Titus	91534			
		91349			
		91533			
GSFC	J. McLean	F227	107 cm (42 in)		Optronics 746/ISIC
	J. Cooper	F268			
		F269			
		F315			
NIST	C. Johnson			PTFE 5.08 cm (2 in)	PR714 SXR
	C. Cromer				
NOAA	D. Clark	F307	Optronics 420M	25.4 cm (10 in) [Small]	
		F308			
		F123			
NRIFS Satlantic	K. Kawasaki S. McLean	91591		43.2 cm (17 in) [Large]	OCR100 (s/n 26)
		91604			
		91615			
SBRC	J. Young§	DXW19			UAXR
UA	S. Biggar	F296			
		F297			
UCSB	D. Menzies	F219	50.8 cm (20 in)	43.2 cm (17 in) [Large] 25.4 cm (10 in) [Small]	OCR100 (s/n 9, 11)
		F303			
		F304			
		F305			
UM	K. Voss§	F12G			
		F12H			
WFF	S. Manizade		76.2 cm (30 in)		

†All plaques used are square and are made of Spectralon with the exception of the NIST plaque, which is round (dimension given is the diameter) and is made of pressed polytetrafluoroethylene (PTFE).

§Did not attend.

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The Second SeaWiFS Intercalibration Round-Robin Experiment, SIRREX-2, June 1993

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Appendix C

Uniformity of the GSFC Sphere

The spatial distribution of the spectral radiance of the GSFC sphere was studied after SIRREX-2; the distribution is asymmetric and the variations are significant when compared to the 1% uncertainty that is required for spectral radiance measurements in support of the SeaWiFS program.

Two independent measurements were done. Using a radiometer consisting of an achromatic lens, a filter, and a silicon photodiode, NASA mapped the spectral radiance in the exit port of the integrating sphere (Fig. C-1). The horizontal and vertical axes are labeled in terms of the stepping motor position; 20 counts corresponds to 2 cm. These data were normalized to the value recorded at the central position, and show a total variation of up to 4%. Using the SXR on March 4, 1994, NIST and NASA measured the spectral radiance in the exit port of the sphere for all of the SXR channels. The target area was about 37 mm. A single horizontal scan was acquired at the central vertical position. These results are shown in Fig. C-2, but now the data are normalized to the average value for each channel. The variation is about 3.5%, and except for the red channel at 772 nm, there is little spectral dependence in the variation.

The magnitude of these variations is greater than what is consistent with the SeaWiFS program goals, since the different transfer radiometers have various field-of-views, and GSFC realizes spectral radiance by averaging over the exit aperture of the sphere. The asymmetry of the variation introduces sensitivity to alignment, and in the case of some multichannel transfer radiometers, orientation. To meet the program goals, it must be possible to repeatedly measure spheres using transfer radiometers without regard to alignment issues.

GLOSSARY

AC Alternating Current

BRDF Bidirectional Reflectance Distribution Function

BSI Biospherical Instruments, Incorporated

BSIXR BSI's Transfer Radiometer

CHORS Center for Hydro-Optics and Remote Sensing

DXW Not an acronym, but a lamp designator.

FEL Not an acronym, but a lamp designator.

GLOBEC Global Ecosystem

GSFC Goddard Space Flight Center

ISIC Integrating Sphere Irradiance Collector

JGOFS Joint Global Ocean Flux Study

L&N Leeds & Northrup

MLML Moss Landing Marine Laboratory

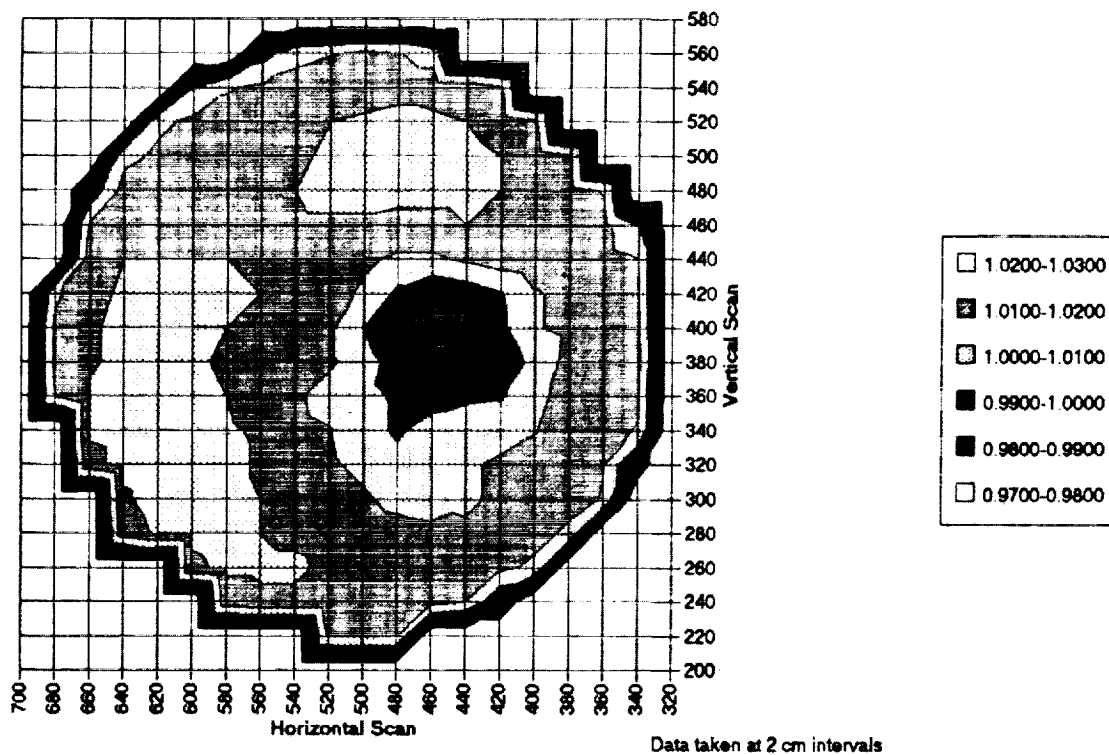


Fig. C-1. The mapped spectral radiance in the exit port of the integrating sphere. The horizontal and vertical axes are labeled in terms of the stepping motor position; 20 counts corresponds to 2 cm.

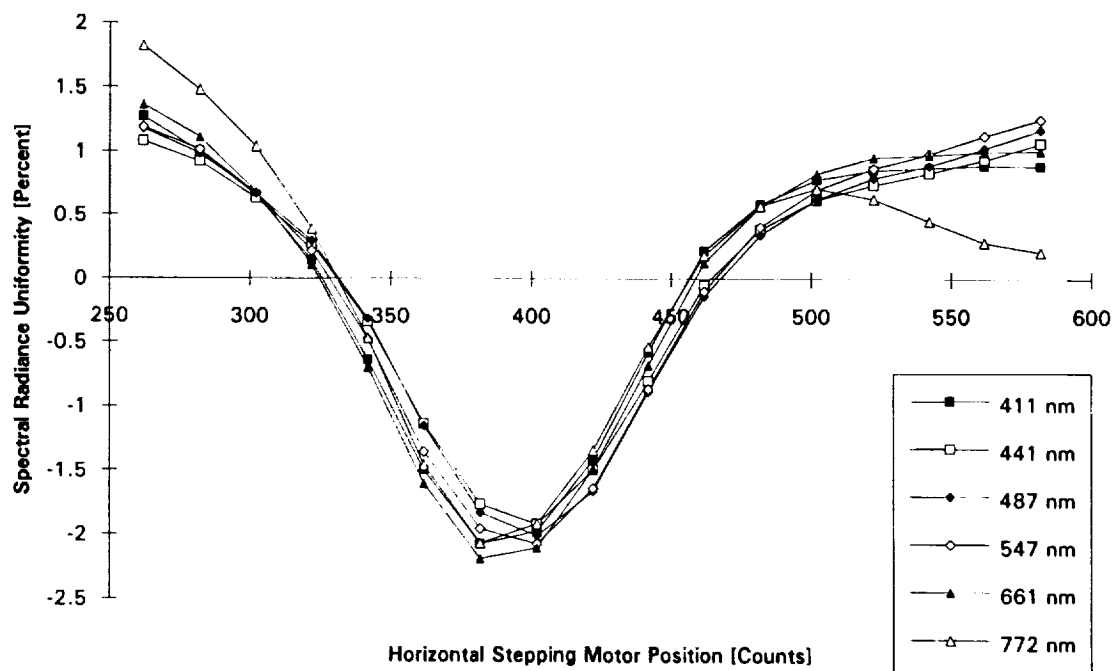


Fig. C-2. GSFC sphere uniformity normalized to average for the channel.

The Second SeaWiFS Intercalibration Round-Robin Experiment, SIRREX-2, June 1993

NASA National Aeronautics and Space Administration
 NRIFS National Research Institute of Far Seas Fisheries (Japan)
 NIST National Institute of Standards and Technology
 NOAA National Oceanic and Atmospheric Administration

PDT Pacific Daylight Time
 PR Photo Research
 PTFE Polytetrafluoroethylene
 QED Quantum Efficient Device

rms root mean square

SBRC (Hughes) Santa Barbara Research Center
 SDSU San Diego State University
 SeaWiFS Sea-viewing Wide Field-of-view Sensor
 SI *Système International d' Unités* or International System of Units
 SIRREX SeaWiFS Intercalibration Round-Robin Experiment
 SIRREX-1 The First SIRREX (July 1992)
 SIRREX-2 The Second SIRREX (June 1993)
 SIRREX-3 The Third SIRREX (to be held in 1994)
 S/N Serial Number
 SXR SeaWiFS Transfer Radiometer
 UA University of Arizona
 UAXR University of Arizona's Transfer Radiometer
 UCSB University of California at Santa Barbara
 UM University of Miami
 WFF Wallops Flight Facility (NASA)

SYMBOLS

δ Relative difference
 $E(\lambda)$ Spectral irradiance.
 $E_{\text{meas}}(\lambda)$ Measured radiance.
 $E_{\text{ref}}(\lambda)$ Reference radiance.
 \bar{F} Arithmetic average.
 $F(\lambda)$ Calibration factor.
 $F(\lambda)$ Average of calibration factors.
 F_i Correction factor.
 $L(\lambda)$ Spectral radiance.
 P_i PR714 raw radiance.
 λ Wavelength.
 σ Standard deviation.

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